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THE DEVELOPMENT OF A PROTOTYPE CONGESTION MANAGEMENT SYSTEM FOR THE STATE OF INDIANA: PHASE I

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PURDUE UNIVERSITY

FINAL REPORT

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16. Abstract

This study details a comprehensive set of guidelines and a work-plan that consists of nine elements that need to be developed in implementing a congestion management system. A procedure has been developed by means of which congestion on roadway links can be identified at a macroscopic level using daily volume counts (ADT) after which, links that are identified as being congested will be subjected to a more detailed microscopic study using hourly volume counts to determine extent, duration and severity of congestion.

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WORKPLAN FOR THE DEVELOPMENT OF THE INDIANA CONGESTION MANAGEMENT SYSTEM

Development of the Indiana congestion management system began in June, 1993. The Joint Highway Research Project of Purdue University and Indiana Department of Transportation undertook a study to develop the framework of a prototype CMS for Indiana. An advisory committee was set up to guide the study. This committee includes representatives from Indiana Metropolitan Planning Organizations (MPOs), Indiana Department of Transportation (INDOT), the Federal Highway Administration (FHWA), and Indiana Department of Environmental Management (IDEM). The list of the CMS Committee is presented in Table 1. The study involved a nationwide survey of state transportation agencies, a mail-back survey of Indiana MPOs, personal interviews with officials of Indiana MPOs, and a comprehensive literature review. Under this study, a prototype congestion management plan (CMP) has been developed. This plan includes all activities that should be completed in developing the Indiana CMS, which agencies should be involved in the process, recommended performance measures and standards, and a procedure to identify and quantify roadway congestion. Using these guidelines, the congestion management agencies - which include the twelve Indiana MPOs and INDOT - would develop management systems specific to their jurisdictions of responsibility. A copy of a report on prototype congestion management plan (CMP) is attached as an annex to this workplan.

1. Congestion Management Agencies

As discussed in the congestion management plan, the Indiana CMS will have two components: an urban CMS and a rural CMS. The urban CMS component will be developed by each of the twelve MPOs and will cover areas under the jurisdiction of each MPO. The rural CMS will be developed by INDOT's Divisions of Roadway Management and Planning and will include all areas not covered by the MPOs. Specific activities which need to be performed are discussed in the congestion management plan. Thus, INDOT and the twelve MPOs will be defined as congestion management agencies (CMAs).

2. Congestion Management Committees

As an initial activity in the development of individual CMS, each congestion management agency will appoint a CMS committee. The agencies that should be represented on this committee are mentioned in the prototype statewide congestion management plan (CMP). The study advisory committee set up for developing the CMP will continue to serve as the statewide CMS Committee.

3. Define Target CMS Networks

The CMS committees will define their region's target CMS network. All elements and links on the network will be identified and classified according to the guidelines set in the CMP. The definition of the target statewide network has already been performed as indicated in the CMP. The specific details of the urban networks will be determined by October, 1994.

4. Establish Program of Data Collection and System Monitoring

Each region will implement a comprehensive data collection and system monitoring program. A plan for this program detailing geographic areas to be covered, data collection responsibilities, time frames, data analysis process, and funding sources, will be developed as part of the initial activities of developing the CMS. This activity will be coordinated with the INDOT's data collection program and should follow the guidelines indicated in the CMP. Based on this plan, data collection and system monitoring activities should be implemented by October, 1995.

5. Status Report on Prevailing Regional Congestion Levels

Performance measures have been identified and standards have been established as part of the CMS study and are discussed in the CMP. The CMAs will use these performance indicators and standards to identify and quantify recurring and nonrecurring congestion in their respective areas' roadway and transit networks. Based on this assessment, a report detailing each region's congestion levels will be prepared. This report will be due whenever the CMS is updated, which is every three years for transportation management areas (TMAs) and every five years for other regions, starting from October, 1995.

6. Report on Congestion Mitigation

A report detailing all strategies identified as appropriate congestion mitigation activities will be prepared. This report will include agencies responsible for the implementation and enforcement of strategies, time frames for implementation, and probable funding sources. An implementation schedule will also be included in this report. All strategies identified by the CMS shall conform with the regional and Statewide planning processes, i.e., TIP and STIP. This report, will be due first time in October, 1995 and thereafter whenever the CMS is updated.

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CHAPTER 1: INTRODUCTION

The annual population of Indiana increased 0.98 percent between 1980 and 1990. During this period, Indiana cities and towns experienced 0.17 percent increase in population growth while rural areas experienced a 2.44 percent increase. While statewide population density is not very high at 157.8 population per square mile (1992), several urbanized areas exist that are experiencing high urban densities resulting in traffic congestion and air pollution. According to the 1990 census, Indianapolis is the 12th most populated city in the U.S. At the same time, Gary, in Northwestern Indiana, recorded the largest loss in population of U.S. cities between 1980 and 1990, with a 23.2 percent decrease in population. Indiana has a high level of industrial growth, particularly in the northern and eastern regions of the State. Emissions from these industrial developments further enhance the traffic congestion and air pollution problems in these areas.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) requires each State to implement six management systems covering all transportation elements. These elements include public transportation facilities, pavements, bridges, intermodal transportation facilities, safety, and congestion. By definition, a Congestion Management System (CMS) is a systematic process for evaluating and developing transportation strategies and plans for addressing existing and future traffic congestion. The Indiana Congestion Management System will consist of two components: an urban component and a rural component. The urban CMS component will be composed of several sub-Congestion Management Systems, to be developed by the Metropolitan Planning Organizations (MPOs) in the State.

The State of Indiana has twelve metropolitan areas that come under the jurisdiction of Metropolitan Planning Organizations. These MPOs cover only 25 of the 92 counties in the State. Of these 12 metropolitan areas, five have been designated as Transportation Management Areas (TMAs), i.e., urbanized areas with over 200,000 population. These areas come under the jurisdiction of the following MPOs: Northwestern Indiana Regional Planning Commission (NIRPC), City of Indianapolis Department of Metropolitan Development (CIDMD), Kentuckiana Regional Planning and Development Agency (KIPDA), Michiana Area Council of Governments (MACOG), and Northeastern Indiana Regional Coordinating Council (NIRCC). Except for the Northeastern Indiana region, all of the other above regions are classified as non-attainment of national ambient air-quality standards. A sixth metropolitan area, which comes under the jurisdiction of the Evansville Urban Transportation Study (EUTS), is not designated as a TMA but is in non-attainment of standard ozone levels. The other six MPOs are Bloomington Area Transportation Study (BATS), Delaware-Muncie Metropolitan Plan Commission (DMMPC), Greater Lafayette Area Transportation and Development Study (GLATDS), Kokomo and Howard County Governmental Coordinating Council (KHCGCC), Madison County Council of Governments (MCCG), and West Central Indiana Economic Development District, Inc. (WCIEDD). The counties under the jurisdiction of the twelve MPOs are shown in Table 1.1, along with their latest population figures, and air quality status. Each of the above twelve MPOs will be required to develop an urban CMS.

Except for the Chicago-Northwestern Indiana area, traffic congestion is not viewed as significant when compared to most other metropolitan areas of similar size in the country. Chicago/Northwestern Indiana is also the only one of the five non-attainment areas that is classified as severe, the other four being classified as marginal (i.e., is now in compliance of air quality standards). Thus, the Chicago/Nortwestern Indiana region should focus its CMS on reducing VMT while the other areas should focus on mobility enhancement and the prevention of congestion from occurring in the future. It should also be noted that several of the nonattainment areas classified as 'marginal' are currently in the process of being reclassified as 'attainment'. These areas will no longer be eligible for Congestion Mitigation and Air Quality (CMAQ) Improvement funding which will be discussed in Chapter 3.

The rural component of the Indiana Congestion Management System will be developed by the Indiana Department of Transportation (INDOT), which also has overall responsibility for coordinating and guiding the development of CMSs in metropolitan areas.

Table 1.1 MPOs that are Required to Develop an Urban CMS

MPO	Counties in Jurisdiction	Population (1990)	% Increase (1980-1990)	Air Quality Status
CIDMD	Marion	797,159	+4.17	Marginal[4]
	Hamilton[1]	108,936	+32.23	Attainment
	Johnson[1]	88,109	+14.07	Attainment
	Boone[1]	38,147	+4.67	Attainment
	Hendricks[1]	75,717	+8.47	Attainment
	Hancock[1]	45,527	+3.61	Attainment
EUTS	Vanderburg	165,058	-1.47	Marginal[3]
	Warrick	44,920	+8.31	Attainment
	Henderson[2]			Attainment
KIPDA	Clark	87,777	-1.19	Moderate[3]
	Floyd	64,404	+5.29	Moderate[3]
	Jefferson[2]	664,937	-2.88	Moderate[3]
	Bullitt[2]	47,567	+9.74	Moderate[3]
	Oldham[2]	33,263	+19.67	Moderate[3]
MACOG	St. Joseph	247,045	+2.25	Marginal[3]
	Elkhart	156,198	+13.74	Marginal[3]
	Marshall	42,182	+7.73	Attainment
NIRCC	Allen	300,836	+2.21	Attainment
NIRPC	Lake	475,594	-9.06	Severe[4]
	Porter	128,932	+7.61	Severe[4]
	LaPorte	107,066	-1.44	Attainment
BATS	Monroe	108,978	-7.34	Attainment
DMMPC	Delaware	119,659	-7.14	Attainment
GLATDS	Tippecanoe	130,598	+7.31	Attainment
KHCGCC	Howard	80,827	-6.98	Attainment
MCCG	Madison	130,669	-6.22	Attainment
WCIEDD	Clay	24,705	-0.63	Attainment
	Parke	15,410	-5.88	Attainment
	Putnam	30,315	+3.95	Attainment
	Sullivan	18,993	-10.02	Attainment
	Vermillion	16,773	-7.99	Attainment
	Vigo	106,107	-5.59	Attainment

1 = Only portions of county. 2 = Counties in Kentucky.
3 = Ozone only. 4 = Ozone and carbon monoxide.

CHAPTER 2: STUDY ELEMENTS

According to the type of activities involved, the Indiana Congestion Management System will consist of nine elements. These elements are:

1. Definition of targeted CMS network and components.
2. Establishment of suitable performance measures.
3. Establishment of performance objectives and standards.
4. Establishment of program of data collection and system monitoring.
5. Identification of roadway and transit system deficiencies.
6. Analysis and evaluation of possible congestion mitigation strategies.
7. Implementation of strategies.
8. Evaluation of effectiveness of implemented strategies.
9. Establishment of a process to periodically update the CMS.

The activities involved with developing these elements are discussed in the following paragraphs. The study approach and research activities are discussed in Appendix E.

Define Targeted CMS Components

The targeted urban CMS roadway network should consist of roadway components functionally classified as freeway, principal arterial and minor arterial. All State highways and principal arterials must be included in the system. Selected minor arterials may be included in the CMS depending on how significant they are in the regional transportation network. The inclusion of local and collector streets is not recommended because these roadways in Indiana are rarely congested and costs associated with collecting data on all these facilities are prohibitively high. A nationwide survey of DOTs also showed that most systems that have been developed so far only included roadways functionally classified as freeway and principal arterial. The classification of roadways as principal or minor arterial, collector or local streets should be done based on a criteria which is consistent Statewide.

Once a highway or roadway is included in the congestion management system, it should not be removed from it. Key intersections should also be included in the CMS. For each roadway type, the total milage within the CMS area and the total number of individual segments (links) should be identified. Key intersections should be identified as signalized or non-signalized. The boundaries of the urban CMS should extend to the MPO planning boundaries, or to the boundaries of the non-attainment areas, whichever is larger.

The transit network in the CMS should include the entire fixed route system classified by route type (express, radial, connector or fixed stop). Transit performance evaluation should be limited to congested corridors as identified through the evaluation of the roadway network. A more detailed evaluation of the transit network will be addressed in the Public Transportation Management System (PTMS). Alternate modes analysis such as bicycles and pedestrians should be addressed primarily through the identification of specific improvement projects or programs.

The rural CMS will include those routes in the National Highway System (NHS) as well as other highways that experience seasonal congestion such as routes leading to recreational areas. This element will address highways of national significance and routes that experience seasonal congestion, and will determine the cause of congestion along those routes. Such problems as bottlenecks, limited bridge capacity, substandard design, and lack of access control should be identified and used as part of the evaluation process. The trip generation characteristics of major generators and the growth patterns which may impact congestion levels on rural CMS routes should also be included in the evaluation.

Establish Performance Measures

There are two primary needs for congestion related performance measures. These are:

1. System monitoring, and
2. Strategy evaluation.

System monitoring can be viewed at several geographic levels: statewide, regional, corridor, subarea and link/intersection.

Strategy evaluation will be necessary in pre-implementation evaluation of strategy alternatives as well as post-implementation strategy monitoring and assessment. Measures that are adequate for system monitoring may not be sensitive to changes in performance levels due to individual strategies, even though those strategies may provide significant benefit to mobility within corridors or subareas. In view of this, two levels of performance measures are proposed, one for system monitoring and one for strategy evaluation.

System Performance Measures

A considerable amount of study was devoted to identifying a suitable performance indicator for roadway congestion. The study involved an extensive literature review, interviews with officials of Indiana MPOs, an assessment of prevailing traffic conditions in urban areas in Indiana and a nationwide survey of State transportation agencies. The study revealed that roadway system performance measures should reflect travel, traffic flow, travel time, delay and air quality. These should also:

- provide the means to evaluate system performance and identify system deficiencies based on accepted standards or objectives,
- provide the means to identify roadway system congestion at a level that would indicate that congestion mitigation measures are needed, and
- be feasible with minimum human and monetary resources necessary to identify system deficiencies adequately.

Potential system performance measures should be evaluated according to the following criteria (J.H.K. & Associates, 1993):

1. General use and understanding among professionals and the public;
2. Sensitivity to changes in supply;
3. Measurable in the field;
4. Translatable into user and environmental costs;
5. Estimated using models;
6. Ease of computation;
7. Applicability to existing databases; and
8. Indicative of traffic congestion.

Based on the above evaluation criteria, two suitable roadway system performance indicators have been identified and are recommended for use in the Indiana CMS. These performance indicators can be determined at low geographic levels and aggregated up to broader geographic levels, thus preserving consistency. Table 2.1 lists the two recommended system performance measures and also indicates the point of collection of the information and how it can be aggregated.

The two performance indicators can be used together to determine how well the system performs in accommodating increases in travel demand. A description of each measure is given in Table 2.1.

Percent of Weekday VMT with v/c > x

The v/c ratio is a key indicator of the degree to which the highway system is being utilized, and it is somewhat sensitive to demand responsive strategies. Vehicle Miles of Travel (VMT) is used primarily as a weighting factor across hours and geographic areas. The data can be collected through a set of volume sampling stations, each of which would represent a section of roadway by direction. Hourly volumes multiplied by miles yields VMT. Each hour is evaluated for its relationship to a v/c threshold. The data can be assembled on a spreadsheet, the size of which would depend on the number of sampling stations.

In evaluating changes in congestion over time, it is important that each hour be evaluated, instead of just the peak hour. In areas where the v/c threshold has been exceeded, congestion worsens through the spreading of the peak. If an hourly dimension is not provided, the capability of evaluating changes in congestion over time (i.e., spreading of the peak) will be lost. The percent VMT with v/c ratio > x can also be specified by peak period, if the period is long enough. Also, for recreational roadways and roadways with seasonal weekend peaks or other unusual peaks, the time period of the analysis should be modified to describe the peak travel conditions.

<u>Total Weekday VMT with v/c Ratio > x</u>

Total VMT is primarily a base to which changes in the percent VMT can be referenced. If the total VMT increases significantly, but the percent VMT at v/c ratio > x remains constant, one can conclude that the system is actually accommodating increases in demand quite well (i.e., congestion would have worsened if measures had not been taken). This is important information for decisionmakers.

In evaluating the above performance measures (v/c ratios), the volumes can be measured directly in the field or estimated using models. Some amount of ambiguity exists, however, with the definition of capacity. If different areas used different definitions for 'capacity' the resulting v/c ratios would not be consistent. This was observed in an evaluation of current traffic conditions in Indiana metropolitan areas identified through a Statewide survey, which is further discussed in Appendix E. A standard definition of 'capacity' should therefore be established. According to Chapter 10 of McShane and Roess (1990), capacity is defined for prevailing roadway, traffic and control conditions on a highway facility. It gives the ideal capacities for multilane highways to be 2000 passenger cars per hour per lane (pcphpl), two lane rural highways to be 2800 passenger cars per hour, total for both directions, and intersection approaches to be 1800 passenger cars per hour of green per lane (pcphplg). These ideal conditions, however, need to be adjusted to obtain prevailing conditions. The adjustment factors are determined with respect to the following:

1. Prevailing geometric conditions. These include adjustments for alignment and design speed, lane width and lateral clearance, and grades.
2. Prevailing traffic conditions. These include adjustments for directional distribution, lane distribution, and percentages of heavy vehicles in

traffic stream (heavy vehicles are classified as trucks, recreational vehicles and buses). The effect of heavy vehicles on roadway capacity will depend on whether the facility is on level, rolling or mountainous terrain.

3. Prevailing control conditions. These include speed limits, lane use controls, traffic signals, and 'STOP' and 'YIELD'signs.

Thus, highway capacity can be obtained from the following equation:

$$c = c_I * f_1 * f_2 * f_3 * \ldots\ldots * f_i$$

where c = capacity of the facility under prevailing conditions,

c_I= capacity of the facility under ideal conditions,

f_i= adjustment factor accounting for non-ideal condition *i* described above. These adjustment factors can be obtained from the <u>Highway Capacity Manual</u> (1985).

This, however, requires a detailed inventory of the roadway network with respect to prevailing geometric, traffic and control conditions. INDOT is currently in the process of accepting bids from contractors to perform a Statewide facility characteristics inventory. This project will identify facility characteristics such as horizontal and vertical curves, grades, number of lanes, median width, lane width, shoulder width, peak parking, type of terrain, passing locations and speed limits. These data, along with prevailing traffic condition data, would be sufficient to determine consistently the capacities of facilities throughout the State. The project will be performed in two stages of six months each, and the results will be available in about 18 months. The study advisory committee has also formed a subcommitte to address issues related to the determination of roadway capacities.

Transit system performance measures have been developed based on transit operating data that can be obtained without too much difficulty from transit operators. Recommended transit system performance indicators are:

1. IVTT: In-vehicle travel time per mile (minutes per mile).
2. Load Factor: The average number of passengers per total vehicle capacity (load factor) on board transit vehicles passing the maximum load point on a route segment.
3. Frequency of Service: Time between arrivals of a transit vehicle at a transit stop in minutes (headway).

These transit performance indicators can be used to determine the effectiveness of the transit system in moving people.

Congestion Strategy Measures of Effectiveness (MOEs)

The pre- and post-implementation evaluation of congestion strategies requires the assessment of strategy impacts. This assessment should give an indication of the effectiveness of the strategy in performing its intended function. A single MOE would not provide the needed level of descriptive power and sensitivity to be applicable to all types of congestion strategies. The recommended roadway system performance measures will not provide the characteristics necessary to evaluate all types of congestion strategies, particularly those that are management related. Therefore, it is recommended that additional MOEs be employed that are tailored to the function of the congestion strategies. A nationwide survey of DOTs was conducted to identify the MOEs that can have significant potential for application to the analysis of congestion strategies and can also be applicable in the State of Indiana. A possible set of such measures is shown in Table 2.2. These MOEs can be estimated using analytical techniques or measured in the field. Table 2.2 also indicates whether the MOE is considered to have primary or secondary application to roadway capacity, transit ridership, transportation demand management (TDM) or non-capacity transportation system management (TSM) type strategies.

A base or existing level should be established for the MOE being used to provide a basis for comparison in the pre- and post-implementation analysis. Also, an appropriate time frame for the pre- and post-implementation analysis of impacts should be established. This could vary by the type of congestion strategy being evaluated. For instance, TDM strategies may require at least a year after implementation for their effects to be fully realized, while the effects of intersection improvements will typically be felt immediately after implementation.

Data collection and analysis techniques of implemented strategies should be consistent with the MOE being employed. Table 2.3 provides information on the data collection and analysis procedures that could be used to evaluate each of the proposed MOEs. The estimation procedures and measurement techniques indicated in Table 2.3 were discussed with officials of MPOs interviewed in the study and they were found to be currently in use or easily implementable in Indiana metropolitan areas.

Establish System Performance Standards

The purpose of performance objectives is to provide a benchmark by which operating conditions can be assessed. When establishing performance objectives and standards, it must be recognized that the public's perception of congestion may vary by area and facility type. For instance, the minimum acceptable level of performance on a principal arterial in the CBD would be lower than that on a minor arterial in a residential zone. Thus, different performance objectives should be established for different facility and area types. These benchmark values should be consistent Statewide. For example, the minimum acceptable level of performance on a principal arterial in the CBD should be the same throughout the State. This makes way for consistent monitoring of congestion levels.

Interviews were conducted of officials of all MPOs in Indiana with a view on evaluating existing roadway conditions, congestion levels and data collection activities. According to this evaluation, the minimum acceptable level of performance in most areas is LOS D and in some urban areas, LOS E is observed during peak periods. A significant proportion of each urban area's network, however, is currently operating under LOS C. Based on this evaluation, recommended thresholds for roadway congestion were identified and are shown in Table 2.4. It should be noted that these values represent the 'x' benchmark values of the recommended performance measures given in Table 2.1. This approach is based on one adopted in developing a congestion management system for the Colorado Department of Transportation (J.H.K. & Associates, 1993). The specific v/c ratios were developed in consultation with MPO officials interviewed in the study.

Transit standards should be established for the frequency and routing of transit services, and for the coordination of transit services provided by separate operators.

1. <u>Routing Standards:</u> Routing standards should be established at the corridor level to provide the

transit operator with maximum flexibility in locating service routes.

2. <u>Frequency Standards:</u> Frequency standards should be determined by considering corridor passenger generating capability, transit system capacity, and service type proposed. Standards for frequency should also be aimed at encouraging ridership.

3. <u>Coordination Standards:</u> Coordination of both schedules and fares should be addressed to minimize transfer inconveniences.

Taking the above into consideration and using the recommended transit performance indicators, conceptual transit performance objectives have been developed, to provide a benchmark for assessing the operating conditions of the transit system. To accommodate variations in the level of demand, these performance objectives are based on sub-area type as well as route type. These standards were recommended for use in the Denver, Colorado metropolitan area by J.H.K. & Associates, in developing a congestion management system for the Colorado Department of Transportation and are shown in Table 2.5. These standards should be applied to the afternoon peak travel period, which corresponds to the peak travel period for transit and the peak congestion period for the roadway system. A similar approach could be adopted for assessing transit operating conditions in Indiana.

According to Table 2.5, the transit performance objectives to be maintained in downtown CBD areas are maximum in-vehicle-travel-time of 5 minutes, load factor at maximum load point of not less than 0.50 and not more than 1.00, and maximum service headway during PM peak period of 30 minutes.

Establish Program of Data Collection and System Monitoring

Data collection and system monitoring requirements for both roadway and transit should be identified, and appropriate time frames established. The data collection program will be a cooperative effort between several agencies, and these agencies should be identified. Also, resources should be allocated, both financial and personnel, for data collection activities. Some of the new planning funds, that will most likely come from the reauthorization legislation, should be devoted to data collection. It must be remembered that system monitoring, as required by the ISTEA, should be performed on a continuing basis.

Two major types of data are required to make the CMS work: data on system performance and evaluation data on actions implemented. These data need to address the movement of people and goods as well as vehicles.

Data Collection for System Monitoring

A comprehensive data collection and system monitoring plan should be established as one of the primary activities of developing the CMS. The monitoring plan should specify such activities as:

- data to be collected,
- data collection frequency,
- data collection locations,
- data collection responsibilities,
- data analysis techniques,
- database management requirements,
- performance analysis reporting, and
- funding sources of data collection activities.

Based on the recommended performance indicators, the data needs for roadway and transit monitoring are discussed below.

Roadway System Monitoring Data Needs

Hourly volume counts will be required at a sufficient number of stations to cover the total CMS roadway network. Multiplying the hourly volumes by the length of the roadway segment or link (in miles), the VMT can be obtained. The data could be assembled on a spreadsheet. Hourly volume counts can be aggregated to daily, weekday, weekend, monthly, seasonal and annual traffic volumes.

INDOT currently maintains ADT data, obtained on each link for a 48 hour period, assembled in spreadsheet format. Hourly counts are also available for each link, for each of the 48 hours. Most of the twelve MPOs currently have a program of data collection and system monitoring underway. The type of data collected in these areas includes ADT. ADT data is being collected in a number of different programs. In most cases, each station is sampled for a period of 48 hours every three years. Some MPOs, like NIRCC, have several permanent count stations. Others, like GLATDS, collect data when needed. In order for the CMS to be implemented successfully, the data collection effort has to be comprehensive - i.e., cover the entire network, and do so on a continuing basis.

Transit System Monitoring Data Needs

All of the data required to derive the transit system performance measures can be obtained from transit operators. Service frequency can be obtained from the transit schedules while IVTT/mile can be obtained from the transit schedules and travel logs. Load factor at maximum load point can be derived from farebox revenues and travel logs.

Data Collection for Strategy Evaluation

Data collection for strategy evaluation should be performed with a view on determining the effectiveness of a given strategy on relieving congestion and enhancing mobility in the area or corridor in which the strategy has been implemented. Table 2.2 shows which MOEs are recommended for which types of strategies: roadway capacity, transit, or non-capacity TDM or TSM.

<u>Identify Roadway and Transit System Deficiencies</u>

One of the biggest issues in the development of the congestion management system was the use of existing data for identifying and quantifying congestion. Currently, weekday volume counts (ADT) are maintained by INDOT in spreadsheet format (LOTUS 123). A methodology has been devised by means of which these data can be updated to reflect links that are congested at a macroscopic level and is described below. Once these congested links have been identified, a more comprehensive study of the extent and duration of congestion can be performed.

The ADT that is maintained in spreadsheet format can be converted to directional peak hour volumes by means of appropriate K and D factors. (see Chapter 4 of McShane and Roess, 1990). The K factors are dependent on the amount of development in the areas surrounding the facility in question. These factors can be used in the following manner (McShane and Roess, 1990):

$$DPHV = ADT * K * D,$$

where DPHV = directional peak hour volume,
ADT = average daily traffic,
K = peak hour volume factor, and
D = peak directional factor.

K and D factors for roadways based on facility type and area type have been developed as part of this study and are discussed in Chapter 4. These factors were developed using the historical data from sixty permanent traffic counting stations in Indiana. Different K and D factors have been developed based on the area type, facility type, season of the year, day of the week, AM peak period, and PM peak period. Using these factors, the ADT data, currently collected by almost all MPOs, can be converted to directional peak hour volumes.

The peak hour volumes can be divided by the peak hour capacities to obtain the peak hour v/c ratios. These v/c ratios can be compared with the established performance standards which are shown in Table 2.4, and the deficient links can be identified, i.e., all links with v/c ratios exceeding the benchmark v/c ratios will be identified.

Once the deficient links are identified, the hourly volume count data can be used to assess the extent and the duration of congestion on those links in the following manner:

$$\text{Percent of Weekday VMT} = \frac{\text{Peak Period Volume} * \text{link length}}{\text{ADT} * \text{link length}}$$

$$\text{Thus, Percent of Weekday VMT} = \frac{\text{Peak Period Volume}}{\text{ADT}}$$

The peak period used in the above calculation will include the total number of hours during which the v/c ratio exceeded the benchmark values. The number of hours during which the v/c ratio exceeds the benchmark v/c ratio would give the duration of congestion.

The severity of congestion will be assessed in the following manner. Each of the links identified to be deficient will be assigned to one of the following three categories:

1. Uncongested - percent of hourly VMT exceeding threshold v/c values identified in Table 2.4 is

less than X percent of weekday VMT. No capital investments nor management responses need to be directed towards these corridors.

2. Moderately Congested - percent of hourly VMT exceeding threshold v/c values identified in Table 2.4 is between X and Y (>X) percent of weekday VMT. Management actions alone may be sufficient to address deficiencies; capital investment need not be directed towards these corridors.

3. Severely Congested - percent of hourly VMT exceeding threshold v/c values identified in Table 2.4 is greater than Y percent of weekday VMT. Management actions alone would be insufficient to address deficiencies; capital investment should be considered.

These X and Y values should be determined on the basis of each area's threshold for congestion, and would typically be in the range of 8 to 17 percent. Thus the congestion levels will be quantified based on the percentage of the weekday VMT that has exceeded the benchmark values for a given roadway segment or intersection.

The identification of congested links will thus be performed at two levels: at a macroscopic level, ADT data can be converted to peak hour volumes using the K and D factors, and deficient links identified; further analysis of these links at a microscopic level, with additional hourly data collection, if necessary, can be performed to determine extent, duration and severity of congestion.

The current procedure to collect the ADT data is to count traffic volumes every three years for a period of 48 hours at each station. The CMS is required to establish a data collection and system monitoring program on a continuing basis. Therefore, it is recommended that sufficient resources be allocated for data collection.

The CMS will also require that all capital investment projects be accompanied by appropriate management actions. Capital investment projects may not be permissible in some severely congested areas due to social, environmental or fiscal constraints. In such areas, TDM and TSM measures alone would be the only possible responses. Also, since capital investment projects in some severely congested areas may not be implementable for a long period of time, interim management actions will need to be considered.

Analyze and Evaluate Possible Congestion Mitigation Strategies

The CMS will produce strategies to address the short and long range congestion problems in the area. It should also produce a prioritized program of projects for inclusion in the regional transportation improvement program (TIP), a financial analysis, and an implementation plan.

The financial analysis should include an estimate of funds available for CMS strategies and projects. An estimate of the areawide congestion costs such as delay and operational costs should also be made.

The implementation plan should identify the proposed method for implementing the CMS strategies and actions. Obstacles for implementing strategies and actions should also be identified. This plan should be developed within the existing Section 134 planning process in cooperation with INDOT and local officials. Institutional and financial barriers towards implementation of the CMS strategies should also be addressed.

All proposed strategies should be evaluated to determine their impact on relieving congestion. A balanced approach to mitigating congestion should be adopted and a wide variety of alternatives should be examined. Initially, alternatives should include transit projects, trip reduction programs and system management projects. Prior to adding additional lanes to a highway or building new roads, all other feasible alternatives should be evaluated. The evaluation should determine which project or combination of projects will most effectively address congestion.

All congestion management strategies should also be evaluated against air quality requirements prior to final adoption to maximize CMS conformity to the State inplementation plan (SIP). Thus, the system monitoring program implemented to determine progress in congestion reduction should also be used to determine progress in meeting with air quality targets. This can be performed using available emissions monitoring software such as MOBILE5.

Congestion mitigation strategies can address the supply of transportation facilities through transportation system management (TSM) or the demand for transportation facilities through transportation demand management (TDM). TSM strategies could be further classified as those that manage existing facilities and those that increase the supply of facilities. TDM strategies could also be further classified as those that manage the existing demand and those that try to prevent or control future demand growth. Each of these four types of congestion mitigation strategies should be separately addressed in a specific program. Transit is expected to play an important role in managing congestion. Therefore, a fifth program will consist of all transit related strategies. Thus, the following five programs will identify appropriate congestion mitigation strategies:

1. Trip reduction and travel demand management program,
2. Transportation systems management program,
3. Land use analysis program,
4. Capital improvement program, and
5. Transit program.

Trip Reduction and Travel Demand Management Program

This program will address all components of the CMS network that are classified as 'moderately congested' as well as those elements that are 'severely congested' but due to social, fiscal, and environmental constraints, cannot be subjected to capital improvement projects. Because of the link between travel demand management and air quality, congestion issues in the Chicago/Northwestern Indiana area, which is in severe non-attainment of air quality standards, and other non-attainment areas, should be addressed predominantly by this program. The objectives of this program are:

1. Improvement of system efficiency by developing measures that will increase the person throughput of the system with minimum capital improvements;
2. Integrate modal options by ensuring that measures chosen are supportive of alternate mode choices;
3. Reduce vehicle trips and vehicle miles traveled by encouraging alternative mode choices;
4. Integrate air quality planning requirements with the transportation planning and programming functions; and
5. Improve the overall system level of service by reducing vehicle demand or by maximizing the person throughput of the system.

Trip reduction and travel demand management strategies should be analyzed and evaluated on the basis of the following criteria:

- public acceptance - marketability of the strategy;
- measurable benefits - cost effectiveness and efficiency; and
- difficulty of implementation - institutional barriers.

Several priority management strategies that could mitigate congestion were identified and evaluated under the above criteria for application in Anchorage, Alaska (Bernadin, Lochmueller & Assocciates, Inc. 1993), which provides a good example. These strategies have been classified according to the following implementation categories:

1. Policy management strategies;
2. Employer-based trip management programs;
3. Work schedule changes;
4. Area-wide single-occupant-vehicle (SOV) reduction incentives;
5. Public transit improvements;
6. HOV lanes;
7. Parking management;
8. Bicycle and pedestrian programs; and
9. Vehicle limitations/restrictions.

A list of strategies along with how they were evaluated according to the above criteria (on a scale of Low, Medium, High) as well as the trip purposes that each strategy is linked to (HBW, HBO, NHB), is shown in Table A1 of Appendix A.

The trip reduction and travel demand management element will promote alternative transportation methods to single-occupant vehicle (SOV) usage, such as carpools, vanpools, bicycles, walking, transit, and park and ride lots. Trips can also be reduced by means of flexible work hours and parking management strategies. This program will also address issues related to intermodal transportation as they are identified in the Intermodal Transportation Management System (IMS) for Indiana.

Transportation System Management Program

This program will address congestion that can be mitigated by means of system management strategies, without significant capital expenditure. The objectives of this program are:

1. To increase the efficiency of the existing transportation system in the immediate future,
2. To minimize the cost of improving the quality of service on, and the efficiency of, the existing transportation system,
3. To minimize the undesirable environmental impacts of existing transportation facilities, and
4. To promote desirable and minimize undesirable social and economic impacts of existing transportation facilities.

The management of pavements, bridges and public transportation facilities will be addressed in this program. This program will also address traffic flow improvements that can be affected at low cost to enhance mobility. Significant improvements in traffic flow can be realized by upgrading and retiming traffic signal facilities. Studies show that of the 240,000 signalized intersections in the United States, about 148,000 are estimated to need substantial upgrading of equipment, while 30,000 simply need to be set properly to reflect current traffic conditions. Annual results between 1983 and 1985 of a signal timing program in California showed that at a cost of $13 million, an estimated $24 million was realized in fuel savings, $31 million in vehicle wear and tear, and $23 million in time savings (ITE, 1989). Therefore, a signal timing and upgrading element will be included in this program that will inventory, analyze, and retime or upgrade equipment of all signal facilities in the network.

A roadway safety element will also be included in this program, and issues identified by the Safety Management System (SMS) can be addressed. Other elements that should be included in the transportation system management program are roadway improvements, incident detection and management, and enforcement of traffic regulations.

Land Use Analysis Program

A land use analysis program is necessary to address future congestion issues. This program should analyze the impacts of land use decisions made by local jurisdictions on regional transportation systems. It should also be able to estimate the costs associated with mitigating those impacts.

All projects should be subjected to a traffic impact analysis. This analysis should be done based on criteria established by the MPO with local governments. Depending on the results of this analysis, mitigating actions should be identified in conformance with CMS standards, and costs associated with those actions estimated. The type of mitigation required will depend on the nature of the impact of the project. Before the project is approved, the agencies responsible for the funding of the mitigations - if any are warranted - will also be identified.

The land use analysis program is an opportunity for local agencies to encourage the implementation of system mitigations (i.e., improvements to public transit services and facilities, improvements to ridesharing services, improved non-motorized facilities, etc.) and non-capital mitigations (i.e., parking policies, transit passes, etc.). Traditional capital improvements may also be necessary in combination with system and non-capital improvements, including highway, roadway and interchange improvements.

There may be a number of options of implementing mitigations including developer exactions, and other state or local funding sources. Regardless of the funding source, capital improvements identified as mitigations should be included in the CMS capital improvement program.

Capital Improvement Program

The capital improvement program should be formatted in a manner that is compatible with the transportation improvement program (TIP). Projects should be ranked in priority order, list project cost, and expected delivery year. The criteria for capital improvement project selection should include that all projects:

1. Maintain or improve traffic level of service and transit performance standards;
2. Mitigate land use impacts; and
3. Conform to vehicle emissions and air quality mitigation standards.

The CMS is to be incorporated into the regional transportation plan action element. Therefore, projects selected for the capital improvement program will need to be consistent with the assumptions, goals, policies, actions and projects identified in the regional transportation plan.

In terms of air quality, the regional transportation plan must conform with the State transportation improvement program (STIP). Therefore, for the CMS capital improvement program to be adopted into the regional transportation plan, it must also conform to the STIP.

The capital improvement program becomes the basis of projects from which the transportation improvement program (TIP) is developed. Therefore, projects that are to be included in the TIP must first be included in the capital improvement program. However, the TIP is a funding constrained document, and therefore inclusion in the capital improvement program will not guarantee a project's funding. The conformance of the CMS with existing plans is further dicussed in Chapter 4.

Transit Program

Transit should be viewed as a primary strategy for alleviating urban congestion. All issues related to the improvement of existing facilities and the increasing of trasit services as identified by the Public Transportation Management System (PTMS) should be addressed in this program. The objectives of this program are:

1. Develop strategies to increase transit ridership, particularly in CBD and other urban areas,
2. Increase transit service coverage, and
3. Enhance coordination between transit operators and major employers/trip generators.

Implementation of Strategies

The CMS should focus on implementation. Examining the feasibility of implementing certain types of actions will require not only undertaking an institutional analysis early in the process, but also conducting a fairly rigorous financial analysis to show that sufficient resources are available to implement the actions chosen as part of the congestion management process. Institutional analysis and assessment must occur early in the process so that respective roles and responsibilities can be identified. Thus, for each strategy or combination of strategies proposed for implementation, the following should be identified:

- an implementation schedule,
- implementation roles and responsibilities, and
- probable funding sources.

Each strategy or combination of strategies should be accompanied by a specific goal to be achieved. This should be done in terms of the appropriate measures of effectiveness for those strategies selected, as identified in Table 2.2. For instance, a ridesharing program to be implemented at a specific employment center should be expected to increase the average vehicle occupancy or reduce the number of vehicle trips by a specified amount within a given time period. The implementation focus should be aimed at achieving these objectives.

Most congestion related strategies provide no more than marginal impact when applied individually, however, when implemented together with other techniques, the effectiveness could be far greater. Thus, carrying out several compatible techniques under one coordinated program not only could improve the benefits from the most promising techniques, but could also achieve significant results from techniques that were only marginally efective when applied individually. NCHRP Report 205 (TRB 1979) has identified eight packages as potentially effective programs on the basis of compatibility of individual techniques and the applicability of combinations of techniques to different types of congestion problems. These components of recommended packages are shown in Table B1 of Appendix B.

Two types of congestion reduction strategy-specific activities or roles have been identified: operational activities and management of operational activities (TRB

1979). Operational activities consist of activities directly related to the functioning of the strategy such as running a ridesharing program or operating a new express bus service. Management of operational activities consists of the management or administrative duties relating to the operation of strategies such as monitoring and evaluating the impact of the ridesharing program or programming modifications for the express bus service. In some cases, such as transit service improvements, the same institution fills both roles, while in other cases, such as work hours rescheduling, different agencies fill these two strategy-specific roles. In addition to these two activities, six others have been found to occur during the actual implementation of congestion reduction strategies (TRB 1979). These activities are:

1. Initiation and promotion of the actual project (rather than just the concept),
2. Funding project start-up costs,
3. Funding project continuation costs (if any),
4. Regulation and licencing of project activity, personnel, clients or riders,
5. Formal approval of the project (apart of the approval process implied in other roles), and
6. Enforcement of operational characteristics and rider or client eligibility.

Thus, altogether eight implementation activities or roles can be identified for congestion reduction strategies. These activities are not common to every type of strategy, but can be identified for most strategies. The institutions filling these essential implementation roles should be identified and communication lines between those institutions and agencies should be established at the planning stages of a project.

In addition to identifying the institutions and agencies involved with implementing congestion reduction strategies, it is also crucial to identify:

1. The factors that induce an institution filling one or more of the eight essential roles to do so willingly and competently,
2. The factors that create support or opposition among other groups and institutions in the community, and
3. The reasons why, and the conditions under which, other community institutions can and do influence the performance of one or more of the eight essential roles by key institutions.

Evaluation of Effectiveness of Implemented Strategies

A process shall be implemented for the periodic assessment of the effectiveness of implemented strategies. This process will involve the appropriate measure of effectiveness for the implemented strategies as identified in Table 2.2. and will determine how well the objectives have been achieved within a defined time frame. If a strategy is not proving to be effective, an alternate strategy will be proposed for implementation.

Periodic Updating of the CMS

A process should be established that would periodically update the congestion management system. It is recommended that the CMS be updated along with the TIP and STIP, and the process should perform the following:

- evaluate the existing CMS network and add any necessary elements/links,
- review and update system performance objectives,
- review and coordinate roadway and transit data collection with data needs for air quality and land use assessments,

- combine information from the individual CMS status reports into a system-wide (i.e., statewide) status report,
- provide a public information program to disseminate information on the operating status of roadway and transit system,
- coordinate with other ISTEA management systems, and
- integrate findings into continuous long-range planning and short-range programming activities.

Each agency responsible for implementing a CMS should produce a status report whenever the CMS is updated. The TIP is updated every three years in TMAs and every five years in other areas, thus the CMS in TMAs will be updated every three years and every five years in other areas, at which time a status report will be due. The status report should include a state of the system report, a performance monitoring report, an effectiveness evaluation report (detailing the effectiveness of implemented strategies), and a CMS master plan report, which describes all CMS programming activities, recommendations and decisions. These status reports will be combined by the State to develop the Indiana State CMS status report to the FHWA.

Table 2.1 Recommended System Performance Indicators

Performance Measure	Point of Collection	Aggregate to
% weekday vehicle miles traveled (VMT) with v/c ratio > x. (x is a defined type v/c threshold and can be translated to LOS)	Link, by direction, by hour	Subarea Corridor Facility Region State
Total weekday VMT with v/c > x. (x is a defined v/c threshold and can be translated to LOS)	Link, by direction, by hour	Subarea Corridor Region State

Table 2.2 Congestion Strategy Measures of Effectiveness (MOEs)

	Strategies			
MOEs	Roadway Capacity	Transit	Non-capacity TDM	Non-capacity TSM
Number of Hours with v/c > x	P	S	S	-
Total trips per mile	P	S	S	P
% VMT with v/c > x	P	S	S	-
% PMT with v/c > x	P	S	S	-
Average vehicle ridership	-	P	P	-
Number of person trips by mode	S	P	P	-
Total trips	-	-	P	-
LOS for links and intersections	P	-	-	P
Delay on links and at intersections	P	-	-	P
Incident duration	-	-	-	P
Average trip travel time	P	P	P	P
Average trip length	S	S	S	-
Vehicle miles of travel (VMT)	P	S	S	-
Person miles of travel	P	P	P	-
Vehicle hours of travel	P	P	P	P

P = primary application
S = secondary application

Source: J.H.K. & Associates, 1993.

Table 2.3 Methods of Quantifying Congestion Strategy MOEs

MOE	Estimation	Measurement
No. of hours with v/c > x	* Regional traffic forecasting model with hourly traffic distribution assumptions * Traffic simulation models * HCM methods to estimate capacity	* Hourly traffic counts with capacity
Travel time per mile:		
Roadway	* Traffic simulation models * HCM Chps. 7, 9 and 11 * Regional traffic forecasting model with enhanced speed-flow curves	* Floating car technique * Video car matching * Aerial video and vehicle tracking
Transit	* Published transit schedules with on-time performance estimates	* Travel time measure-ments by route
% VMT with v/c > x	* Regional traffic forecasting models * Traffic simulation models	* Link length and hourly traffic counts
% PMT with v/c > x	* Regional traffic * forecasting models * Traffic simulation models * Vehicle occupancy estimates	* Link length and hourly traffic counts * Vehicle occupancy counts

Table 2.3, continued

MOE	Estimation	Measurement
Average vehicle ridership	* Surveys * Focus groups * TDM analysis models	* Vehicle occupancy counts * Transit ridership * Bicycle usage * Pedestrian counts * Traffic counts * Surveys
Number of person trips by mode	* Mode choice model * Regional traffic forecasting model	* Surveys * Transit ridership * Bicycle usage * Rideshare partici-pation * Pedestrian count * Traffic counts
Total trips	* Trip generation element of the regional traffic forecasting model * Elasticities based on experience * ITE trip generation rates	* Trip counts by mode * Surveys
LOS for links and/or intersections	* HCM procedure * Traffic simulation models * Regional traffic forecasting model	* Traffic counts * Delay measure-ment * Travel time studies * Density measure-ment

Table 2.3, continued

MOE	Estimation	Measurement
Delay on links or at intersections	* HCM Chps. 9 and 11	* Field delay measurement
Incident duration	* Experience from other metropolitan areas * Freeway traffic simulation * Analytical models	* Incident detection time and response time measurement * Incident site clearance time measurement
Average trip travel-time	* Regional traffic forecasting model * Published transit schedules	* O-D surveys * Trip logs * Transit rider surveys
Average trip length	* Regional traffic forecasting model	* O-D surveys * Trip logs * Transit rider surveys
Vehicle Miles of Travel (VMT)	* Regional traffic forecasting model * Traffic simulation models * Transit schedules and route lengths * Average trip length x number of trips	* Traffic counts * Vehicle trip logs

Table 2.3, continued

MOE	Estimation	Measurement
Person Miles of Travel (PMT)	* Regional traffic forecasting model (requires VO estimate) * Traffic simulation model (requires VO estimate) * Mode choice model	* Trip logs * O-D surveys * Transit rider surveys
Vehicle Hours of Travel (VHT)	* Regional traffic forecasting model * Transit schedules * Traffic simulation model * HCM Chps. 7, 9 and 11	* Trip logs * Travel time studies * Delay measurements

Source: J.H.K. & Associates, 1993.

Table 2.4 Recommended Benchmark v/c Ratios for Identifying Congestion

	Area Type			
Facility Type	Major Traffic Generators[1]	Other Urban[2]	Suburban	Rural
Key Intersections	0.90	0.90	0.80	0.70
Freeways	0.80	0.90	0.80	0.70
Principal Arterials	0.90	0.80	0.80	0.70
Minor Arterials	0.90	0.80	0.80	0.70
Collector	0.90	0.80	0.80	0.70

1 - Includes shopping centers, universities, airports, schools, hospitals, etc.
2 - Includes urban areas that do not have special traffic generators.

Table 2.5 Transit Performance Objectives

Route Type		Major Traffic Generators	Urban	Suburban
		Area Type		
Express	TT	5.0	3.5	2.5
	LF	0.50 - 1.00	0.40 - 1.00	0.30 - 1.00
	FS	30	30	30
Local Radial	TT	5.0	4.0	3.5
	LF	0.50 - 0.90	0.40 - 0.90	0.30 - 0.90
	FS	10	20	30
Local Connective	TT	N/A	4.0	3.5
	LF	N/A	0.30 - 0.90	0.30 - 0.90
	FS	N/A	20	30
Circulator	TT	5.0	3.5	3.0
	LF	0.50 - 0.85	0.40 - 0.85	0.30 - 0.85
	FS	20	20	20

TT = In-vehicle tavel time per mile (minutes per mile) during the p.m. peak traffic hour.
LF = The load factor at the maximum load point on a route segment during the p.m. peak traffic hour.
FS = Headway (frequency of service) during the p.m. peak traffic hour.

Source: J.H.K. & Associates, 1993.

CHAPTER 3: INSTITUTIONAL ISSUES

In developing and implementing the CMS for Indiana, the involvement of several agencies and organizations will be necessary. In fact, the communication and cooperation among relevant parties is a critical element in all stages of the development and implementation of the CMS. The CMS should also fit in with the current and future plans and programs of the INDOT and the MPOs. A single project can be the result of several planning or programming activities. Thus, if all plans and programs are structured similarly, the additional work required can be minimized and optimal allocation of resources could be achieved. The sources and amount of funds available for the development and subsequent implementation of the CMS will also be of importance, and the availability of funds may govern how the CMS is structured. These institutional issues are addressed in this section.

Institutional Involvement

Several agencies and organizations are relevant to the development and the implementation of the Indiana congestion management system. While most of these agencies will be involved in the identification and implementation of congestion management strategies, some agencies will be involved only with a few aspects of the CMS. Listed below are the institutions that have been identified to be relevant to the development and implementation of the Indiana CMS.

1. Indiana Department of Transportation (INDOT) - Division of Roadway Management and Division of Planning,

2. Metropolitan Planning Organizations (MPOs),
3. Indiana Department of Environmental Management (IDEM),
4. Local Government Agencies,
5. Transit Operators,
6. Labor Unions,
7. Public Service Commission,
8. Indiana State Police,
9. City Police Departments,
10. Sheriffs' offices,
11. Emergency service delivery organizations (e.g., tow truck companies),
12. Trade organizations
13. News media, and
14. Citizens Group Committees.

Each MPO should appoint a CMS Committee which should include appropriate representatives from the above institutions. The various roles and responsibilities of these agencies and organizations are discussed below.

Indiana Department of Transportation: INDOT's Division of Roadway Management will be responsible for the overall development of the Statewide CMS, while the Division of Planning will be responsible for primarily overseeing its implementation. The Division of Roadway Management will obtain status reports of all urban CMSs from the MPOs and also include the status report of the rural CMS, which INDOT is also responsible for developing, and report to the USDOT. The Division of Planning will serve as the facilitator as well as the coordinator to the MPOs in their efforts in developing and coordinating the urban CMS in their respective jurisdictions, in cooperation with the Division of Roadway Management. Thus, the Divisions of Roadway Management and Planning will jointly monitor the development of all urban CMSs. INDOT will also be responsible for the allocation of State funding and most

Federal funding for capital improvement programs. It will also determine the feasibility of certain projects that are programmed for Federal or State funding. It should be noted that the Public Transportation Section of the INDOT should also be part of the effort in developing the CMS in Indiana as it is responsible for the Public Transportation Facilities Management System (PTMS) and it coordinates the activities of the transit operators in Indiana.

Metropolitan Planning Organizations: All MPOs will be responsible for developing an urban CMS in accordance with the guidelines set by the State. Each MPO should set up a committee to implement the urban CMS within its jurisdiction. Specific activities to be performed by the MPOs include:

1. Identifying target urban CMS network;
2. Implementing/updating program of data collection and system monitoring;
3. Identifying congested regions/corridors;
4. Identifying and evaluating congestion mitigation strategies with respect to costs, environmental impacts, and urgency;
5. Staging projects by estimating funding, and developing an implementation schedule.
6. Identifying institutions to be involved, their roles and responsibilities in the implementation of congestion reduction strategies;
7. Incorporating the findings of the CMS to the TIP; and
8. Preparing a CMS status report to the State.

The MPOs will therefore be responsible for keeping open the channels of communication between the various agencies, and ensuring the full cooperation and participation of all relevant organizations in the planning and decisionmaking process.

<u>Local Government Agencies</u>: Transportation units of local governments should be consulted with respect to monitoring requirements for their portions of the CMS network. They may also provide information on existing and planned transportation networks within their general plans. The implementation of some congestion reduction strategies will require the cooperation of local government agencies and it is advisable to involve them as early as possible during the planning stages of the urban CMS.

<u>Transit Operators</u>: As transit operational improvements will play an important role in the CMS, transit operators will also be included during the planning stages, to ensure that transit planning and programming can be adequately integrated. The cooperation of transit providers is essential in maintaining transit operational standards. The data needed for deriving transit performance indicators are available from transit operators and the Public Transportation Section of INDOT will coordinate the transit data collection effort.

<u>Indiana Department of Environmental Management</u>: IDEM will be responsible for monitoring of air quality and emissions levels. This is essential for the CMS to meet the federal requirements. IDEM will coordinate with MPOs on a periodic basis to evaluate the air quality impacts of implemented congestion reduction strategies. A representative of IDEM in the CMS committee would allow specific transportation related actions and needs pertaining to air quality to be identified and programmed into the CMS.

<u>Indiana State Police/City Police Departments/Sheriffs' Offices</u>: The cooperation of the police is essential in implementing strategies that require enforcement of traffic laws and regulations. The success of such strategies as HOV lanes, parking restrictions or auto-free zones, depend primarily on enforcement. The police also need to be informed

in time of traffic operational changes made to the transportation network, rerouting of traffic due to construction, incident management, etc.

Labor Unions: Work hours rescheduling and transit operational changes, which are two common congestion reduction techniques, may cause conflicts with established labor regulations and commitments, such as payment of overtime and minimum work hour weeks. Therefore, the programming of such congestion reduction techniques into the CMS would require the cooperation of appropriate labor unions.

Public Service Commission: Techniques such as carpooling, vanpooling, transit service expansions, and those that involve zoning regulations must be approved by the Public Service Commission. Thus, a representative of the Commission would be able to provide input on the legislative requirements of programmed congestion reduction strategies.

Emergency Service Delivery Agencies: Non-recurring congestion due to incidents can cause a significant amount of congestion. An incident management program should be implemented to address this type of congestion. Such a program could simply mean an agreement with a local tow truck agency to respond promptly to any incident that may cause a stoppage or reduction in traffic flow. Thus, at least one tow truck agency should be represented in the CMS committee.

Trade Organizations: Organizations such as the AAA Hoosier Motor Club and the Indiana Motor Truck Association (IMTA) could provide public motorists' and trucking agencies' perspectives relevant to the development and implementation of the Indiana CMS.

News Media: The cooperation of the news media is essential in getting the public to accept and understand the need for congestion management. If the media is informed of the advantages and benefits of implementing specific congestion reduction strategies, they will be better able to convince the public.

Citizens Group Committees: Citizens group committees constitute a forum where members of the public can voice their support, or more often, opposition, to actions undertaken by transportation and other agencies. Involving citizens group members in the planning stages of a CMS will foster greater understanding between transportation professionals and the public and allow for disputes regarding programmed activities to be dealt with at a preliminary stage rather than after implementation.

The CMS's Role in the Regional and Statewide Planning Process

The CMS is a newly required program. In order for it to be effective, it must fit in with the MPO's existing framework of planning activities. A schematic diagram of how the CMS will fit into each MPO's long- range transportation plan and transportation improvement program (TIP) and eventually to the State's implementation plan is shown in Figure 3.1. The CMS will essentially replace the existing Transportation System Management Program (TSM). It will, however, differ from the TSM in several ways (FHWA, 1991):

1. The emphasis on implementation and on the role of implementation agencies will, of necessity, force State and local agencies to deal with the institutional structure for making congestion management decisions.
2. The fundamental basis of a CMS is the measurement of system performance. Identifying performance measures may take the planning processs a step closer towards

becoming a program management strategy.

3. The TSM process lacked a systematic data collection process. The CMS, however, depends on such a process.
4. The CMS will make a more careful examination of the linkage between air quality planning and congestion management.
5. Even though transit operational strategies were considered to be a component of TSM plans, they were rarely considered from an integrated, multi-modal perspective. The CMS, particularly in urbanized areas, will place a great deal of emphasis on transit strategies.

The CMS can, therefore, be viewed as a more comprehensive form of the TSM program with more specific requirements. As shown in Figure 3.1, at the regional level, the urban CMS will feed into the regional transportation inprovement program. The State's implementation plan will be developed from the regional TIPs of all twelve MPOs - which incorporates urban CMS programming activities - and rural CMS programming activities.

Funding Sources

The major source of funding assistance for congestion reduction measures is the Federal Government, in particular, the USDOT. Funding sources for congestion reduction programs at the federal level include matching grants and loans for transportation improvement from FHWA and FTA within the USDOT; planning and community development loans and grants from the U.S. Department of Housing and Urban Development (HUD); grants for local public works from the Economic Development Administration; special transportation aid to low-income, elderly and handicapped under programs of the U.S. Department of Health, Education and Welfare; rural transportation assistance from the U.S. Department of Agriculture; and General Revenue Sharing under Public Law 92-512. The State commonly assists communities in meeting part of the local share of federal matching grants, and may provide technical assistance and sponsor demonstrations, with funds obtained through general or gasoline tax revenues. The State may also create special taxing authorities, such as transit districts, authorize special sales tax assessments within a designated transportation region, or approve the issuance of bonds to finance major transportation improvements. The following is a list of the funding programs of FHWA and FTA:

Highway Programs:

1. National Highway System (NHS)
2. Surface Transportation Program (STP)
3. Congestion Mitigation and Air Quality Improvement Program (CMAQ)
4. Bridge Program
5. Interstate Maintenance Program
6. Interstate Substitution Program
7. Minimum Allocation Program
8. Donor State Bonus Program

Mass Transit Programs

1. Transit Formula Programs (Section 9, Section 16(b)(2)and Section 18)
2. Section 3 Discretionary and Formula Capital Program (New Starts, Rail Modernization, Bus and Other)
3. Transit Planning and Research Program

Under the ISTEA of 1991, TMAs that include non-attainment areas for carbon monoxide and ozone may not use federal funds for highway projects which significantly increase single-occupant-vehicle (SOV) capacity, unless they are part of an approved CMS.

Special emphasis is given to the Congestion Mitigation and Air Quality (CMAQ) Improvement program, which is a primary source of funding for all congestion mitigation activities and directs funds towards transportation projects in Clean Air Act non-attainment areas. These funds may be used for transportation control measures (TCMs) and programs designed to help implement transportation/air quality plans and attain the national ambient air quality standards for carbon monoxide (CO) and Ozone (O_3).

Indiana has five non-attainment areas that are eligible for funding under this program. These are Chicago-Northwestern Indiana (CO and O_3), Evansville (O_3), Indianapolis (CO and O_3), Louisville (O_3), and South Bend (O_3), as indicated in Table 1.1. Some of these areas are currently in the process of being reclassified as attainment areas. These areas will then no longer be eligible for CMAQ funding.

Typical CMAQ projects can be approved by the Environmental Protection Agency (EPA) as TCMs and receive credit for emission reductions. Examples of TCMs that are listed in Section 108(f) of the CAAA and are also included in ISTEA are shown in Table 3.1.

Projects excluded from CMAQ funding by legislation are any programs that:

- reduce emissions from extreme cold-start conditions,
- encourage the removal of pre-1980 vehicles, and
- increase road capacity for SOVs (ie, the addition of new, general purpose lanes or the construction of new highways).

The CMAQ program also does not provide funds for maintenance costs incurred on existing systems, and will only fund operating expenses under limited circumstances. Two funding requirements apply to the CMAQ Program:

1. Funds must be spent in a non-attainment area, and
2. The money must be spent on projects that reduce O_3 precursors and CO from transportation sources.

The federal share for most eligible CMAQ projects is 80 percent (or 90 percent if used on the Interstate System). Title 23 of the United States Code, specifies that activities such as traffic control signalization and commuter carpooling and vanpooling may be funded at 100 percent. Pedestrian and bicycle programs must be funded at a Federal share of 80 percent by law.

In addition to the above federal funding programs, there are several special projects and provisions throughout the ISTEA that require separate funding. Of these projects, Indiana has been provided funding for the following.

- $1.8 million for the construction of a four-lane road and overpass in Merrillville;
- $9.5 million to construct a four-lane highway from Lafayette to Fort Wayne following existing Indiana 25 and US 24 routes;
- $23.7 million to improve the Bloomington to Newberry segment of the Indianapolis to Memphis, TN high priority corridor;
- $0.32 million to conduct a feasibility and economic study to widen US Route 24 from Fort Wayne to Toledo, OH as part of the Lafayette to Toledo corridor;
- $1.0 million to study linkage roads to connect Lake Shore Drive and surrounding facilities in Lake, Porter and Laporte counties;
- $1.0 million for acquisition of the West Lake Corridor right-of-way between Munster and Hammond;

- $1.5 million to widen Willow Creek Road in Portage to four lanes;
- $4.3 million for various improvements to Ridge Road to relieve congestion in Hobart, Lake Station and New Chicago;
- $10.0 million for the State Road 67 widening project in Muncie;
- $3.3 million for the Columbus Entranceway project in Columbus;
- $2.2 million for the extension of US 12/20 to Lake Michigan in Gary;
- $24.3 Million for the Lafayette Railroad Relocation project;
- $3.8 million for the construction of an extension of Interstate 69 to link Evansville and Indianapolis; and
- $8.5 million for the East Chicago Marina access road.

Table 3.1 TCMs Eligible for CMAQ Funding (Section 108(f)(1)(A) of CAAA of 1990) and are Also Included in ISTEA

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(1) Programs for improved public transit.

(2) Restriction of certain roads or lanes to, or construction of such roads or lanes for use by, passenger buses or high- occupancy vehicles (HOV).

(3) Employer based transportation management plans, including incentives.

(4) Trip-reduction ordinances.

(5) Traffic flow improvement programs that achieve emissions reductions.

(6) Fringe and transportation corridor parking facilities serving multiple occupancy vehicle programs or transit service.

(7) Programs to limit or restrict vehicle use in downtown areas or other areas of emission concentration particularly during periods of peak use.

(8) Programs for the provision of all forms of high-occupancy, shared-ride services.

(9) Programs to limit portions of road surfaces or certain sections of the metropolitan area to the use of non-motorized vehicles or pedestrian use, both as to time and place.

(10) Programs for secure bicycle storage facilities and other facilities, including bicycle lanes, for the convenience and protection of bicyclists, in both public and private areas.

(11) Programs to control extended idling of vehicles.

(12) Employer sponsored programs to permit flexible work schedules.

Table 3.1, continued

(13)	Programs and ordinances to facilitate non-automobile travel, provision and utilization of mass transit, and to generally reduce the need for single-occupant vehicle (SOV) travel, as part of transportation planning and development efforts of a locality, including programs and ordinances applicable to new shopping centers, special events, and other centers of vehicle activity.
(14)	Programs for new construction and major reconstruction of paths, tracks or areas solely for use by pedestrian or other non-motorized means of transportation when economically feasible and in the public interest.

Source: US DOT, 1991.

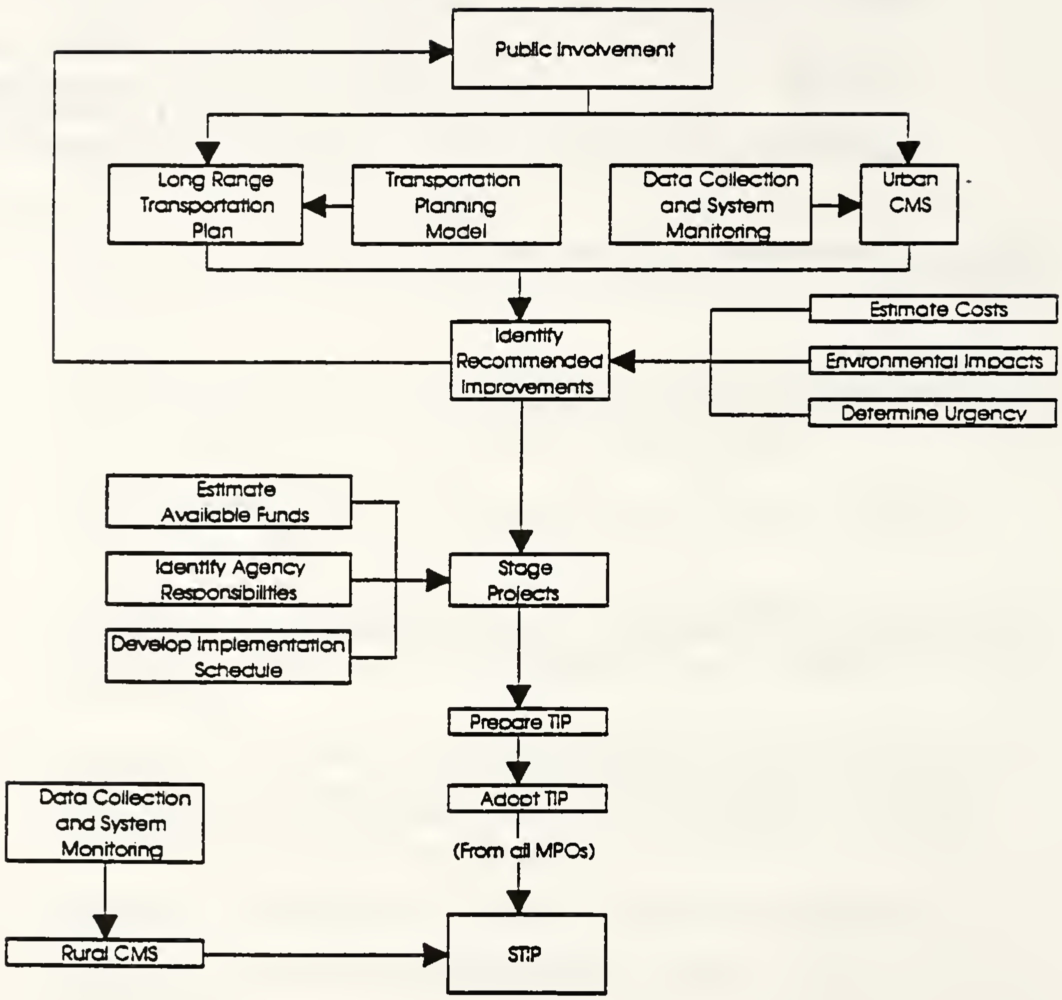

Figure 3.1 Structure of the CMS Within the TIP and STIP Process

CHAPTER 4: DEVELOPMENT OF PEAK HOUR (K) AND PEAK DIRECTIONAL (D) FACTORS

In Chapter 2, it was determined that a preliminary analysis of congestion at a macroscopic level would be performed in order to identify links that are congested and are in need of further study. This analysis will only use average daily traffic (ADT) data. The peak hour or 'K' factor will be used to determine the percentage of daily traffic observed during the peak hour, and the directional or 'D' factor will be used to determine the volume in the peak direction of flow during the peak hour. This determination will be done according to the following equation (McShane and Roess, 1990):

$$DPHV = ADT * K * D,$$

where DPHV = directional peak hour volume,
ADT = average daily traffic,
K = peak hour volume factor, and
D = peak hour directional factor.

This section will discuss the procedure and the results obtained in developing these factors.

The data used to develop these factors were obtained from the traffic counts on the sixty permanent counting stations in the State of Indiana. The counts are recorded on an hourly basis throughout the year and summarized in an annual report, aggregated to daily, weekly, monthly and yearly volumes. Traffic volumes are counted in each direction of travel and summarized by direction as well as in combination. The counting stations have been assigned to five different types of roadway functional classifications. These are: Urban Interstate/Urban Freeway, Urban Arterial, Rural Interstate, Rural Arterial, and Rural Collector. Historical data from 1991 through 1993 were used in the analysis.

Objective of Analysis

The objective of the following analysis was to determine what the seasonal and daily effects are, if any, with respect to the peak volume ('K') and peak directional ('D') factors, and to identify suitable factors for determining peak hour volumes and peak hour directional distributions from average daily traffic (ADT) counts.

Collection of Data

The data files for all the stations for the period between January 1991 and December 1993 were used to obtain the data needed for the analysis. Several 'C' programs were written to extract the required data fields from the raw data files. The data included in the analysis were year, facility type, month, season of year, month of season, day of week, station identification number, AM and PM 'K' factors, and AM and PM 'D' factors. The AM and PM 'K' factors were obtained by identifying the highest volume of hourly traffic counted during the AM and PM periods, and dividing that value by the total traffic count for that day. The AM and PM 'D' factors were obtained by identifying the direction with the higher volume of traffic during the AM and PM peak periods and dividing those volumes by the total peak-hour volumes for both directions. The data were coded by season of year and month of season, with season 1, 2, 3 and 4 being spring (March through May), summer (June through August), fall (September through November), and winter (December through February), respectively. Month one would therefore be the first month of the season. Thus, the third month of the second season was coded as 2 3, and represented August, which is the third month of summer. Day of week was coded as 1 through 7 with 1 being Sunday and 7 being Saturday.

Care was taken to avoid using data that showed obvious deviations from normal traffic flows. This could have been the result of the roadway being closed for a period of the day or the malfunctioning of the traffic counter. Also, in order to eliminate station effects, all of the data were obtained from every station sampled.

Analysis of Data

The data were analyzed by means of the Analysis of Variance (ANOVA) procedure using SAS statistical software (Montgomery, 1991). The ANOVA procedure was performed using the following factor levels:

- year,
- station identification number,
- day of week,
- season of year, and
- month of season.

This procedure involved studying the effect of each of the above factors on the dependent variables, which in this case were:

- AM 'K' factor,
- PM 'K' factor,
- AM 'D' factor, and
- PM 'D' factor.

The effect of the factor levels on the above dependent variables are the 'main effects'. In some instances, the difference in response between the levels of one factor is not the same at all levels of the other factors. This occurs due to the interaction between factors (Montgomery, 1991). In this study, the following interaction effects were studied:

- year * day of week,
- year * season of year,
- year * month of season,
- season of year * month of season,
- day of week * season of year,
- year * day of week * season of year, and
- year * day of week * month of season.

The ANOVA procedure was performed by type of facility for the above main factor levels and interaction terms. The significance of each factor level and interaction term was determined using the F-statistic. The hypotheses tested were:

H_0: Factor effect = 0, (for all factors and interaction terms)
H_a: Factor effect $\neq$ 0.

If the mean square of a factor level or interaction term is significantly larger than the mean squared error, i.e., the F-statistic is greater than a critical F value (for a given level of significance), the alternate hypothesis, H_a, can be concluded. i.e., there would be sufficient evidence to conclude that a factor effect or interaction effect exists.

Results

A summary of the analysis of variance (ANOVA) procedure results are shown in Tables 4.1 through 4.5. The ANOVA procedure showed that at the 99 percent confidence level, the F-statistic was greater than the critical F value for the main factor levels 'Day of the Week' and 'Season of the Year' for all four dependent variables - AM and PM 'K' and 'D' factors. Thus, there is sufficient evidence to conclude that factor effects exist for those two levels. The F-statistic for the interaction term 'Day of Week * Season of the Year' was also greater than the critical F value at the 99 percent confidence level in all but the AM 'D' and PM 'K' factors for facility type 'Rural Collector'. This indicates that there exists a seasonal effect by day of week. The results also showed that the factor level 'Station Identification Number' is very significant, indicating that the exact location of the facility has an effect on the AM and PM 'K' and 'D' factors. But by obtaining the data for all of the factor levels from each station, this effect was eliminated. The factor level 'Month of Season' did not appear to be significant except for AM 'K' and PM 'D' factors for Rural Collector, AM 'K' factor for Rural Arterial and AM 'D' factor for Rural Interstate. i.e., AM and PM 'K' and 'D' factors do not vary significantly by month of season except for the above facility types. It should be noted that the ANOVA sum of squares for the effect of month within each season can be determined by summing the sums of squares of the factor 'month' and the interaction term 'season * month'.

The average variations in the AM and PM 'K' and 'D' factors by day of the week and by season of year for all five facility types are represented graphically in Figures D1 through D40 of Appendix D. These graphs represent the variations in the percent of average daily traffic during the peak period ('K' factor), and percent of peak period traffic in the peak direction ('D' factor), by day of the week and by week of the season. It can be seen from these figures that the seasonal variability is low for the 'K' factors while there appears to be significantly more seasonal variability in the 'D' factors. According to these graphs, the seasonal variations of the dependent variables by day of the week can be classified as 'Low', 'Medium', and 'High' as listed below. Factors that do not show significant seasonal variability for all seasons are classified as 'Low'. Factors that show seasonal variability for some seasons and not others are classified as 'Medium' and those that show significant seasonal variability for all four seasons are classified as 'High'.

Low seasonal variation by day of week for:

AM 'K' factor for Urban Freeway/Interstate,
AM 'K' factor for Urban Arterial,
AM 'K' factor for Rural Arterial,
AM 'K' factor for Rural Collector, and
PM 'K' factor for Urban Freeway/Interstate.

Medium seasonal variation by day of week for:

AM 'K' factor for Rural Interstate,
PM 'K' factor for Urban Arterial,
PM 'K' factor for Rural Interstate,
PM 'K' factor for Rural Arterial,
PM 'K' factor for Rural Collector, and
PM 'D' factor for Urban Freeway/Interstate.

High seasonal variation by day of week for:

AM 'D' factor for Urban Freeway/Interstate,
AM 'D' factor for Urban Arterial,
AM 'D' factor for Rural Interstate,
AM 'D' factor for Rural Arterial,
AM 'D' factor for Rural Collector,
PM 'D' factor for Urban Arterial,
PM 'D' factor for Rural Interstate,
PM 'D' factor for Rural Arterial, and
PM 'D' factor for Rural Collector.

Recommended Factors

In view of the above results, for cases where seasonal variation by day of the week is low, a single factor can be used for all seasons. The highest factors from all the four seasons were selected for each day. For cases with medium seasonal variation, only the seasons that show significant variability should be accounted for. Thus, the factors were selected for the seasons that show significant variability, and for the other seasons. The former were selected as those factors obtained for that season for which significant variability exists. The factors for the remaining seasons were selected by obtaining the highest factor from each of the remaining seasons for each day. For cases with high seasonal variability, the factors were selected from each of the four seasons for each day of the week. These adjustment factors are shown in Tables 4.6 through 4.8.

The factors to be used to identify congestion at a macroscopic level were selected from Tables 4.6 through 4.8 as the highest values from each factor type for each type of facility. The reasoning behind this is that if the highest percentage of average daily traffic observed during the peak hour on any day of the year is below the bechmark value for congestion, then that facility would not be congested at any other time. These recommended values are shown in Table 4.9. Thus, these values can be used in the macroscopic identification of congestion as discussed in Chapter 2.

Further Work

In order to complete the macroscopic identification of congestion, a comprehensive data collection and system monitoring program must be implemented. The data collected must reflect accurate average daily traffic (ADT) counts. This data can be set up on a spreadsheet, the size of which will depend on the number of links sampled. A simple computer program could be written to read these data, and identify any congested links based on the 'K' and 'D' factors discussed above and by means of the performance indicators and standards identified in Chapter 2. For example, if the ADT for a particular link is 25,768 vehicles per day, and the facility is classified as Urban Arterial, the AM and PM 'K' and 'D' factors to be used can be selected from Table 4.9 to be the following:

AM 'K'	0.074
PM 'K'	0.080
AM 'D'	0.555
PM 'D'	0.581

Thus, the AM and PM directional peak hour volumes (DPHV) can be determined to be:

AM DPHV = 25,768 * 0.074 * 0.555 = 1,058
PM DPHV = 25,764 * 0.080 * 0.581 = 1,198

An inventory of facility characteristics should also be made to determine the capacities on all the links in the network. Once the capacities are known, the v/c ratios can be determined. For the above example, if the directional capacity was determined to be 1,200 vehicles per hour, the v/c ratios can be determined to be:

AM v/c ratio = 1,058/1,200 = 0.882
PM v/c ratio = 1,198/1,200 = 0.998

Comparing these directional peak hour volumes with the benchmark v/c ratio of 0.90 from Table 2.4, this link will be identified as being congested and be subjected to further analysis, or uncongested. Thus, it can be seen from the above that this link is congested during the PM peak hour and not congested during the AM peak hour. Further analysis of the hourly traffic volumes will give the extent and duration of congestion as discussed in Chapter 2.

A simple computer program can be written to perform the above. The results of this macroscopic analysis will classify a link as either 'congested' - in which case further analysis would be required using hourly traffic counts - or 'uncongested' - in which case the link will be eliminated from further analysis. This procedure will reduce the total number of links to a manageable amount.

Table 4.1 Analysis of Variance for Urban Freeway/Interstate

Factor Type	Source	DOF	ANOVA SS	F-Statistic	Pr > F
AM 'K'	Year	2	0.0003	1.15	0.3175
AM 'K'	Station ID	9	0.0440	39.79	0.0001
AM 'K'	Day of Week	6	0.2565	347.99	0.0001
AM 'K'	Season	3	0.0042	11.30	0.0001
AM 'K'	Month of Season	2	0.0003	1.24	0.2896
AM 'K'	Year* Day	12	0.0018	1.20	0.2757
AM 'K'	Year* Season	6	0.0008	1.06	0.3828
AM 'K'	Year*Month	4	0.0004	0.78	0.5362
AM 'K'	Season*Month	6	0.0068	9.17	0.0001
AM 'K'	Day*Season	18	0.0095	4.30	0.0001
AM 'K'	Year*Day*Season	36	0.0065	1.47	0.0351
AM 'K'	Year*Day*Month	36	0.0044	0.98	0.4954
PM 'K'	Year	2	0.0034	6.71	0.0012
PM 'K'	Station ID	9	0.3405	147.57	0.0001
PM 'K'	Day of Week	6	0.2801	182.09	0.0001
PM 'K'	Season	3	0.0143	18.58	0.0001
PM 'K'	Month of Season	2	0.0009	1.68	0.1857
PM 'K'	Year* Day	12	0.0015	0.49	0.9225
PM 'K'	Year* Season	6	0.0021	1.35	0.2327
PM 'K'	Year*Month	4	0.0004	0.34	0.8511
PM 'K'	Season*Month	6	0.0049	3.17	0.0042
PM 'K'	Day*Season	18	0.0139	3.00	0.0001
PM 'K'	Year*Day*Season	36	0.0096	1.04	0.4068
PM 'K'	Year*Day*Month	36	0.0163	1.77	0.0030
AM 'D'	Year	2	0.0469	7.49	0.0006
AM 'D'	Station ID	9	3.2977	117.07	0.0001
AM 'D'	Day of Week	6	0.9921	52.83	0.0001
AM 'D'	Season	3	0.2756	29.35	0.0001
AM 'D'	Month of Season	2	0.0028	0.45	0.6354
AM 'D'	Year* Day	12	0.0363	0.97	0.4790
AM 'D'	Year* Season	6	0.0008	0.04	0.9997
AM 'D'	Year*Month	4	0.0269	2.15	0.0720
AM 'D'	Season*Month	6	0.1136	6.05	0.0001
AM 'D'	Day*Season	18	0.1446	2.57	0.0003
AM 'D'	Year*Day*Season	36	0.1151	1.02	0.4335
AM 'D'	Year*Day*Month	36	0.0839	0.74	0.8666
PM 'D'	Year	2	0.1671	40.91	0.0001
PM 'D'	Station ID	9	12.2773	667.78	0.0001
PM 'D'	Day of Week	6	2.8705	234.19	0.0001
PM 'D'	Season	3	0.0941	15.36	0.0001
PM 'D'	Month of Season	2	0.0204	4.98	0.0069
PM 'D'	Year* Day	12	0.0435	1.78	0.0463
PM 'D'	Year* Season	6	0.1439	11.74	0.0001
PM 'D'	Year*Month	4	0.0215	2.62	0.0329
PM 'D'	Season*Month	6	0.1187	9.68	0.0001
PM 'D'	Day*Season	18	0.1635	4.45	0.0001
PM 'D'	Year*Day*Season	36	0.0682	0.93	0.5948
PM 'D'	Year*Day*Month	36	0.0573	0.78	0.8259

Table 4.2 Analysis of Variance for Urban Arterial

Factor Type	Source	DOF	ANOVA SS	F-Statistic	Pr > F
AM 'K'	Year	2	0.0001	1.08	0.3396
AM 'K'	Station ID	13	0.3508	531.14	0.0001
AM 'K'	Day of Week	6	0.3583	1,175.43	0.0001
AM 'K'	Season	3	0.0018	12.05	0.0001
AM 'K'	Month of Season	2	0.0005	4.72	0.0089
AM 'K'	Year* Day	12	0.0026	4.20	0.0001
AM 'K'	Year* Season	6	0.0012	3.89	0.0007
AM 'K'	Year*Month	4	0.0012	5.99	0.0001
AM 'K'	Season*Month	6	0.0075	24.46	0.0001
AM 'K'	Day*Season	18	0.0100	10.89	0.0001
AM 'K'	Year*Day*Season	36	0.0027	1.48	0.0311
AM 'K'	Year*Day*Month	36	0.0018	1.00	0.4646
PM 'K'	Year	2	0.0008	1.07	0.3422
PM 'K'	Station ID	13	0.6637	135.70	0.0001
PM 'K'	Day of Week	6	0.4241	187.88	0.0001
PM 'K'	Season	3	0.0404	35.79	0.0001
PM 'K'	Month of Season	2	0.0015	1.98	0.1387
PM 'K'	Year* Day	12	0.0108	2.40	0.0043
PM 'K'	Year* Season	6	0.0025	1.09	0.3652
PM 'K'	Year*Month	4	0.0010	0.68	0.6036
PM 'K'	Season*Month	6	0.0128	5.65	0.0001
PM 'K'	Day*Season	18	0.0241	3.56	0.0001
PM 'K'	Year*Day*Season	36	0.0192	1.42	0.0504
PM 'K'	Year*Day*Month	36	0.0197	1.45	0.0386
AM 'D'	Year	2	0.1249	49.03	0.0001
AM 'D'	Station ID	13	6.7842	409.71	0.0001
AM 'D'	Day of Week	6	0.2958	38.70	0.0001
AM 'D'	Season	3	0.1146	30.00	0.0001
AM 'D'	Month of Season	2	0.0026	1.03	0.3573
AM 'D'	Year* Day	12	0.0327	2.14	0.0120
AM 'D'	Year* Season	6	0.0463	6.05	0.0001
AM 'D'	Year*Month	4	0.0170	3.33	0.0098
AM 'D'	Season*Month	6	0.0444	5.81	0.0001
AM 'D'	Day*Season	18	0.0539	2.35	0.0010
AM 'D'	Year*Day*Season	36	0.0389	0.85	0.7250
AM 'D'	Year*Day*Month	36	0.0445	0.97	0.5195
PM 'D'	Year	2	0.0148	3.61	0.0270
PM 'D'	Station ID	13	12.2820	463.71	0.0001
PM 'D'	Day of Week	6	1.2195	98.95	0.0001
PM 'D'	Season	3	0.1775	28.81	0.0001
PM 'D'	Month of Season	2	0.0126	3.06	0.0469
PM 'D'	Year* Day	12	0.0483	1.96	0.0237
PM 'D'	Year* Season	6	0.0207	1.68	0.1209
PM 'D'	Year*Month	4	0.0215	2.62	0.0332
PM 'D'	Season*Month	6	0.1091	8.85	0.0001
PM 'D'	Day*Season	18	0.1923	5.20	0.0001
PM 'D'	Year*Day*Season	36	0.0385	0.52	0.9922
PM 'D'	Year*Day*Month	36	0.0502	0.68	0.9284

Table 4.3 Analysis of Variance for Rural Interstate

Factor Type	Source	DOF	ANOVA SS	F-Statistic	Pr > F
AM 'K'	Year	2	0.0001	1.73	0.1777
AM 'K'	Station ID	8	0.0386	133.12	0.0001
AM 'K'	Day of Week	6	0.2460	1,130.58	0.0001
AM 'K'	Season	3	0.0253	232.49	0.0001
AM 'K'	Month of Season	2	0.0002	3.15	0.0429
AM 'K'	Year* Day	12	0.0014	3.14	0.0002
AM 'K'	Year* Season	6	0.0009	3.90	0.0007
AM 'K'	Year*Month	4	0.0005	3.16	0.0132
AM 'K'	Season*Month	6	0.0096	44.09	0.0001
AM 'K'	Day*Season	18	0.0086	13.13	0.0001
AM 'K'	Year*Day*Season	36	0.0017	1.31	0.1022
AM 'K'	Year*Day*Month	36	0.0041	3.13	0.0001
PM 'K'	Year	2	0.0002	0.50	0.6086
PM 'K'	Station ID	8	0.0588	30.31	0.0001
PM 'K'	Day of Week	6	0.5022	344.90	0.0001
PM 'K'	Season	3	0.0260	35.71	0.0001
PM 'K'	Month of Season	2	0.0009	1.85	0.1578
PM 'K'	Year* Day	12	0.0028	0.95	0.4931
PM 'K'	Year* Season	6	0.0015	1.03	0.4031
PM 'K'	Year*Month	4	0.0024	2.47	0.0424
PM 'K'	Season*Month	6	0.0050	3.40	0.0023
PM 'K'	Day*Season	18	0.0226	5.18	0.0001
PM 'K'	Year*Day*Season	36	0.0095	1.09	0.3252
PM 'K'	Year*Day*Month	36	0.0120	1.37	0.0670
AM 'D'	Year	2	0.0099	3.36	0.0349
AM 'D'	Station ID	8	0.3281	27.80	0.0001
AM 'D'	Day of Week	6	0.4376	49.45	0.0001
AM 'D'	Season	3	0.0618	13.95	0.0001
AM 'D'	Month of Season	2	0.0228	7.74	0.0004
AM 'D'	Year* Day	12	0.0156	0.88	0.5671
AM 'D'	Year* Season	6	0.0478	5.41	0.0001
AM 'D'	Year*Month	4	0.0411	6.96	0.0001
AM 'D'	Season*Month	6	0.0954	10.77	0.0001
AM 'D'	Day*Season	18	0.1040	3.92	0.0001
AM 'D'	Year*Day*Season	36	0.0425	0.80	0.7972
AM 'D'	Year*Day*Month	36	0.0456	0.86	0.7090
PM 'D'	Year	2	0.0190	4.14	0.0159
PM 'D'	Station ID	8	2.3752	129.52	0.0001
PM 'D'	Day of Week	6	0.3280	23.85	0.0001
PM 'D'	Season	3	0.0386	5.61	0.0008
PM 'D'	Month of Season	2	0.0168	3.67	0.0256
PM 'D'	Year* Day	12	0.0264	0.96	0.4845
PM 'D'	Year* Season	6	0.0794	5.77	0.0001
PM 'D'	Year*Month	4	0.0640	6.98	0.0001
PM 'D'	Season*Month	6	0.0834	6.07	0.0001
PM 'D'	Day*Season	18	0.2237	5.42	0.0001
PM 'D'	Year*Day*Season	36	0.0657	0.80	0.8023
PM 'D'	Year*Day*Month	36	0.1056	1.28	0.1225

Table 4.4 Analysis of Variance for Rural Arterial

Factor Type	Source	DOF	ANOVA SS	F-Statistic	Pr > F
AM 'K'	Year	2	0.0004	2.98	0.0507
AM 'K'	Station ID	11	0.2767	432.56	0.0001
AM 'K'	Day of Week	6	0.5719	1.639.02	0.0001
AM 'K'	Season	3	0.0043	24.84	0.0001
AM 'K'	Month of Season	2	0.0011	9.40	0.0001
AM 'K'	Year* Day	12	0.0013	1.85	0.0361
AM 'K'	Year* Season	6	0.0006	1.68	0.1209
AM 'K'	Year*Month	4	0.0006	2.62	0.0329
AM 'K'	Season*Month	6	0.0060	17.25	0.0001
AM 'K'	Day*Season	18	0.0115	10.94	0.0001
AM 'K'	Year*Day*Season	36	0.0037	1.75	0.0035
AM 'K'	Year*Day*Month	36	0.0053	2.52	0.0001
PM 'K'	Year	2	0.0015	1.64	0.1949
PM 'K'	Station ID	11	0.3171	61.43	0.0001
PM 'K'	Day of Week	6	0.4164	147.89	0.0001
PM 'K'	Season	3	0.1205	85.56	0.0001
PM 'K'	Month of Season	2	0.0035	3.67	0.0255
PM 'K'	Year* Day	12	0.0063	1.11	0.3432
PM 'K'	Year* Season	6	0.0020	0.72	0.6348
PM 'K'	Year*Month	4	0.0070	3.72	0.0050
PM 'K'	Season*Month	6	0.0665	19.75	0.0001
PM 'K'	Day*Season	18	0.0396	4.69	0.0001
PM 'K'	Year*Day*Season	36	0.0183	1.08	0.3358
PM 'K'	Year*Day*Month	36	0.0173	1.02	0.4313
AM 'D'	Year	2	0.0056	1.44	0.2364
AM 'D'	Station ID	11	1.3002	60.68	0.0001
AM 'D'	Day of Week	6	0.2297	19.65	0.0001
AM 'D'	Season	3	0.1844	31.55	0.0001
AM 'D'	Month of Season	2	0.0206	5.29	0.0051
AM 'D'	Year* Day	12	0.0218	0.93	0.5149
AM 'D'	Year* Season	6	0.0305	2.61	0.0158
AM 'D'	Year*Month	4	0.0022	0.28	0.8905
AM 'D'	Season*Month	6	0.1238	10.59	0.0001
AM 'D'	Day*Season	18	0.1523	4.34	0.0001
AM 'D'	Year*Day*Season	36	0.0699	1.00	0.4754
AM 'D'	Year*Day*Month	36	0.0707	1.01	0.4556
PM 'D'	Year	2	0.0274	4.51	0.0111
PM 'D'	Station ID	11	7.9497	237.46	0.0001
PM 'D'	Day of Week	6	0.8211	44.97	0.0001
PM 'D'	Season	3	0.0742	8.12	0.0001
PM 'D'	Month of Season	2	0.0043	0.71	0.4911
PM 'D'	Year* Day	12	0.0377	1.03	0.4147
PM 'D'	Year* Season	6	0.0063	0.34	0.9143
PM 'D'	Year*Month	4	0.0280	2.30	0.0565
PM 'D'	Season*Month	6	0.1091	5.98	0.0001
PM 'D'	Day*Season	18	0.7101	12.96	0.0001
PM 'D'	Year*Day*Season	36	0.1103	1.01	0.4577
PM 'D'	Year*Day*Month	36	0.0993	0.91	0.6294

Table 4.5 Analysis of Variance for Rural Collector

Factor Type	Source	DOF	ANOVA SS	F-Statistic	Pr > F
AM 'K'	Year	2	0.0018	11.27	0.0001
AM 'K'	Station ID	14	0.4351	400.34	0.0001
AM 'K'	Day of Week	6	0.6459	1,386.63	0.0001
AM 'K'	Season	3	0.0031	13.41	0.0001
AM 'K'	Month of Season	2	0.0025	16.19	0.0001
AM 'K'	Year* Day	12	0.0021	2.30	0.0065
AM 'K'	Year* Season	6	0.0004	0.78	0.5889
AM 'K'	Year*Month	4	0.0009	2.79	0.0249
AM 'K'	Season*Month	6	0.0133	29.63	0.0001
AM 'K'	Day*Season	18	0.0078	5.60	0.0001
AM 'K'	Year*Day*Season	36	0.0056	2.00	0.0003
AM 'K'	Year*Day*Month	36	0.0029	1.05	0.3899
PM 'K'	Year	2	0.0022	1.72	0.1789
PM 'K'	Station ID	14	1.7977	197.40	0.0001
PM 'K'	Day of Week	6	0.5012	128.41	0.0001
PM 'K'	Season	3	0.2018	103.41	0.0001
PM 'K'	Month of Season	2	0.0044	3.37	0.0344
PM 'K'	Year* Day	12	0.0076	0.97	0.4753
PM 'K'	Year* Season	6	0.0105	2.70	0.0127
PM 'K'	Year*Month	4	0.0096	3.69	0.0053
PM 'K'	Season*Month	6	0.0954	24.44	0.0001
PM 'K'	Day*Season	18	0.0218	1.86	0.0146
PM 'K'	Year*Day*Season	36	0.0233	0.99	0.4794
PM 'K'	Year*Day*Month	36	0.0257	1.10	0.3184
AM 'D'	Year	2	0.0085	1.72	0.1788
AM 'D'	Station ID	14	5.0671	147.14	0.0001
AM 'D'	Day of Week	6	0.3811	25.82	0.0001
AM 'D'	Season	3	0.1549	20.99	0.0001
AM 'D'	Month of Season	2	0.0056	1.14	0.3193
AM 'D'	Year* Day	12	0.0303	1.03	0.4213
AM 'D'	Year* Season	6	0.0174	1.18	0.3158
AM 'D'	Year*Month	4	0.0113	1.15	0.3312
AM 'D'	Season*Month	6	0.0399	2.70	0.0127
AM 'D'	Day*Season	18	0.0483	1.09	0.3533
AM 'D'	Year*Day*Season	36	0.0652	0.74	0.8753
AM 'D'	Year*Day*Month	36	0.1119	1.26	0.1335
PM 'D'	Year	2	0.0515	5.19	0.0056
PM 'D'	Station ID	14	15.1973	218.83	0.0001
PM 'D'	Day of Week	6	1.8226	61.24	0.0001
PM 'D'	Season	3	0.5253	35.30	0.0001
PM 'D'	Month of Season	2	0.1315	13.25	0.0001
PM 'D'	Year* Day	12	0.0447	0.75	0.6991
PM 'D'	Year* Season	6	0.0512	1.72	0.1119
PM 'D'	Year*Month	4	0.0317	1.60	0.1725
PM 'D'	Season*Month	6	0.2037	6.84	0.0001
PM 'D'	Day*Season	18	0.2920	3.27	0.0001
PM 'D'	Year*Day*Season	36	0.2416	1.35	0.0771
PM 'D'	Year*Day*Month	36	0.1418	0.79	0.8058

Table 4.6 Factors that Indicate Low Seasonal Variability

Facility Type	Factor	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Urban Freeway/Interstate	AM 'K'	0.068	0.058	0.058	0.057	0.058	0.053	0.070
Urban Arterial	AM 'K'	0.069	0.061	0.060	0.060	0.061	0.059	0.074
Rural Arterial	AM 'K'	0.074	0.062	0.060	0.059	0.061	0.056	0.075
Rural Collector	AM 'K'	0.074	0.062	0.060	0.060	0.062	0.059	0.076
Urban Freeway/Interstate	PM 'K'	0.082	0.080	0.076	0.079	0.075	0.078	0.064

Table 4.7 Factors that Indicate Medium Seasonal Variability

Facility Type	Factor	Season	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Rural Interstate	AM 'K'	Summer	0.067	0.066	0.062	0.061	0.062	0.058	0.075
		Other	0.065	0.062	0.059	0.058	0.061	0.055	0.074
Rural Interstate	PM 'K'	Summer	0.077	0.059	0.062	0.063	0.060	0.070	0.057
		Other	0.085	0.064	0.062	0.065	0.067	0.078	0.062
Urban Arterial	PM 'K'	Winter	0.078	0.075	0.072	0.073	0.075	0.065	0.060
		Other	0.080	0.080	0.079	0.078	0.077	0.073	0.064
Rural Arterial	PM 'K'	Winter	0.078	0.067	0.057	0.064	0.061	0.060	0.052
		Other	0.082	0.072	0.071	0.071	0.072	0.072	0.059
Rural Collector	PM 'K'	Winter	0.065	0.052	0.050	0.052	0.051	0.047	0.044
		Other	0.073	0.063	0.060	0.061	0.061	0.061	0.054
Urban Freeway/Interstate	PM 'D'	Summer	0.549	0.589	0.582	0.576	0.577	0.571	0.533
		Other	0.555	0.597	0.592	0.590	0.584	0.574	0.558

Table 4.8 Factors that Indicate High Seasonal Variability

Facility Type	Factor	Season	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Urban Freeway/Interstate	AM 'D'	Spring	0.546	0.550	0.566	0.560	0.559	0.533	0.544
		Summer	0.536	0.537	0.559	0.546	0.547	0.530	0.538
		Fall	0.543	0.546	0.565	0.564	0.553	0.528	0.563
		Winter	0.553	0.552	0.572	0.573	0.566	0.538	0.548
Urban Arterial	AM 'D'	Spring	0.550	0.535	0.542	0.539	0.538	0.539	0.538
		Summer	0.549	0.533	0.536	0.534	0.535	0.537	0.542
		Fall	0.555	0.540	0.537	0.536	0.539	0.540	0.548
		Winter	0.555	0.544	0.542	0.546	0.544	0.545	0.546
Rural Interstate	AM 'D'	Spring	0.550	0.533	0.532	0.530	0.526	0.536	0.551
		Summer	0.531	0.529	0.530	0.530	0.529	0.531	0.550
		Fall	0.536	0.528	0.530	0.531	0.530	0.534	0.560
		Winter	0.539	0.537	0.537	0.538	0.538	0.540	0.549
Rural Arterial	AM 'D'	Spring	0.544	0.543	0.549	0.540	0.542	0.536	0.548
		Summer	0.545	0.537	0.536	0.533	0.538	0.536	0.558
		Fall	0.553	0.543	0.542	0.540	0.543	0.538	0.556
		Winter	0.552	0.553	0.552	0.550	0.551	0.548	0.550
Rural Collector	AM 'D'	Spring	0.565	0.557	0.554	0.556	0.555	0.552	0.548
		Summer	0.561	0.551	0.551	0.552	0.553	0.559	0.550
		Fall	0.569	0.555	0.554	0.556	0.553	0.556	0.553
		Winter	0.578	0.558	0.557	0.563	0.559	0.559	0.556
Urban Arterial	PM 'D'	Spring	0.547	0.573	0.574	0.574	0.573	0.565	0.553
		Summer	0.557	0.570	0.569	0.570	0.567	0.566	0.551
		Fall	0.548	0.579	0.579	0.576	0.573	0.576	0.556
		Winter	0.546	0.581	0.579	0.579	0.577	0.579	0.573
Rural Interstate	PM 'D'	Spring	0.566	0.541	0.538	0.537	0.539	0.547	0.572
		Summer	0.556	0.546	0.549	0.545	0.547	0.541	0.555
		Fall	0.553	0.544	0.537	0.540	0.541	0.542	0.548
		Winter	0.543	0.552	0.543	0.544	0.543	0.543	0.554
Rural Arterial	PM 'D'	Spring	0.564	0.586	0.584	0.578	0.578	0.584	0.562
		Summer	0.593	0.580	0.577	0.575	0.576	0.587	0.566
		Fall	0.568	0.588	0.587	0.583	0.581	0.593	0.562
		Winter	0.546	0.593	0.593	0.594	0.584	0.594	0.578
Rural Collector	PM 'D'	Spring	0.573	0.608	0.607	0.603	0.598	0.603	0.588
		Summer	0.583	0.604	0.597	0.605	0.598	0.595	0.583
		Fall	0.577	0.609	0.608	0.614	0.607	0.611	0.587
		Winter	0.578	0.620	0.612	0.613	0.616	0.622	0.613

Table 4.9 Recommended Values for 'K' and 'D' Factors

Facility Type	Factor Type	Recommended Value
Urban Freeway/Interstate	AM 'K'	0.070
	PM 'K'	0.082
	AM 'D'	0.573
	PM 'D'	0.597
Urban Arterial	AM 'K'	0.074
	PM 'K'	0.080
	AM 'D'	0.555
	PM 'D'	0.581
Rural Interstate	AM 'K'	0.075
	PM 'K'	0.085
	AM 'D'	0.560
	PM 'D'	0.572
Rural Arterial	AM 'K'	0.075
	PM 'K'	0.082
	AM 'D'	0.558
	PM 'D'	0.594
Rural Collector	AM 'K'	0.076
	PM 'K'	0.073
	AM 'D'	0.578
	PM 'D'	0.620

CHAPTER 5: SUMMARY AND CONCLUSIONS

The Indiana Congestion Management System will be developed as two components - an Urban CMS to be developed by each of the twelve Metropolitan Planning organizations and a Rural CMS to be developed by the Indiana Department of Transportation. Each area's CMS will consist of the following nine elements:

1. Definition of targeted CMS network and components,
2. Establishment of suitable performance measures,
3. Establishment of performance objectives and standards,
4. Establishment of program of data collection and system monitoring,
5. Identification of roadway and transit system deficiencies,
6. Analysis and evaluation of possible congestion mitigation strategies,
7. Implementation of strategies,
8. Evaluation of the effectiveness of implemented strategies, and
9. Establishment of a process to periodically update the CMS.

Two types of performance indicators have been identified - performance measures for system monitoring and performance measures for strategy evaluation. The performance measures for system monitoring include performance indicators for roadways and for transit. The recommended performance measures for roadways are:

Percent of Weekday VMT with v/c ratio > x, and
Total Weekday VMT with v/c > x,

- where the x values represent benchmark v/c ratios that define congestion by facility and area type.

The performance indicators for transit are:

1. In vehicle travel time per mile,
2. Load factor at maximum load point, and
3. Frequency of service.

Performance standards for roadway and transit elements have also been established. Performance measures for strategy evaluation will depend on the type of strategies selected. The MPOs will be responsible for collecting the required data to derive the performance indicators.

A procedure has been developed to identify congested links at a macroscopic level using the average daily traffic data. 'K' and 'D' factors have been developed that could reduce the ADT data to directional peak hour volumes, which can then be evaluated using the established performance measures and standards as to whether a particular link is congested. If the link is found to be congested, it will be selected for further analysis at a microscopic level using hourly volume counts. In this manner, the extent, duration and severity of congestion can be determined. If a link is found to be uncongested, it will be eliminated from further analysis. This procedure will reduce the analysis of a large amount of data from several thousand links on a given network, to a manageable amount.

The mitigation of congestion will be addressed through the following five programs:

1. Trip reduction and travel demand management program,
2. Transportation systems management program,
3. Land use analysis program,
4. Capital improvement program, and
5. Transit program.

The CMS will replace the existing Transportation System Management Program (TSM) and will provide information for the regional and Statewide transportation improvement programs (TIP and STIP). The emphasis of the CMS will be on implementation with greater focus on transit and other multimodal alternatives. Even though the CMS will address Statewide congestion, greater emphasis will be given to air quality nonattainment areas and transportation management areas (TMAs).

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APPENDICES

Appendix A: Demand Management Strategies

Table A1 Evaluation of Demand Management Strategies

Strategy	Public Acceptance	Measurable Benefits	Difficulty of Implementation	Linked Trip Purposes
Policy and Management				
Access management	Low	High	Low	HBW
Trip Reduction Ordinance	Medium	High	Medium	HBW, HBO
Land use policies to reduce SOV's				
Site design criteria to improve transit usage	High	Medium	Medium	HBW, HBO, NHB
Land use policies for improved transit access	Medium	Medium	Low	HBW, HBO, NHB
Parking requirements in zoning codes	Medium	Medium	Low	HBW, HBO, NHB
Ordinance to require provision of bicycle facilities	High	Medium	Low	HBW, HBO, NHB
Education programs	High	Medium	Medium	HBW, HBO, NHB
Auto restricted zones	Medium	Medium	Medium	HBW
HOV Lanes				
Arterial concurrent-flow HOV lanes	Medium	Medium	Low	HBW, HBO
HOV applicability	Medium	Medium	Low	HBW, HBO
Bicycle and Pedestrian Programs				
Bicycle plans and maps	High	High	Low	HBW, HBO, NHB
Bicycle lockers, racks and other storage facilities	High	High	Low	HBW, HBO, NHB
Bicycle routs, lanes and paths	High	Medium	Medium	HBW, HBO, NHB
Sidewalk and walkway facilities	High	High	Low	HBW, HBO, NHB
Pedestrian connections with transit	High	High	Low	HBW, HBO, NHB
Safety considerations for sidewalks and walkways	High	Medium	Low	HBW, HBO, NHB
Areawide SOV Reduction Incentives				
Areawide commute management organization	High	High	Low	HBW
Park and ride lots	High	High	Medium	HBW
Work Schedule Changes				
Alternative work schedules	High	High	Low	HBW
Telecommuting	High	Medium	Low	HBW

Table A1, continued

Strategy	Public Acceptance	Measurable Benefits	Difficulty of Implementation	Linked Trip Purposes
Employer-Based Trip Management Programs				
Ridesharing programs	High	High	Low	HBW
Priority parking for carpools/vanpools	High	Medium	Low	HBW
Employer subsidized transit use	High	Medium	Low	HBW, HBO
On-site employer transportation coordinator	Medium	Medium	Low	HBW
Rideshare/transit/bicycle marketing information programs	Medium	Medium	Low	HBW
Guaranteed ride home programs	High	Medium	Low	HBW
Employee transportation allowance	High	Medium	Low	HBW, HBO
Eliminate subsidised employee parking	Low	Medium	Low	HBW
Showers and clothing lockers for bicyclists/pedestrians	High	Medium	Medium	HBW
Parking Management				
Public sector parking pricing	Low	Medium	Low	HBW, HBO, NHB
On-street parking controls	Low	Medium	Low	HBW, HBO, NHB
Goods movement management	Medium	Medium	Medium	HBW, HBO, NHB
Preferential parking for HOV's	High	Medium	Low	HBW
Parking supply control	Low	High	Low	HBW, HBO
Improve Public Transit				
Route and schedule improvements	High	High	Low	HBW, HBO, NHB
Increased frequency	High	High	Low	HBW, HBO, NHB
Transit operations monitoring	High	Medium	Low	HBW, HBO
Bus maintenance improvements	High	Medium	Low	HBW, HBO, NHB
Transit passenger amenities	High	Medium	Low	HBW, HBO, NHB
Transit marketing and informational programs	High	Medium	Low	HBW, HBO, NHB
Monthly transit passes	Medium	Medium	Low	HBW, HBO, NHB
Improved feeder bus service	Medium	Medium	Low	HBW
Improved express bus service	Medium	Medium	Low	HBW, HBO
Park and ride facilities	Medium	High	Medium	HBW, HBO
Road operational changes	High	Medium	Low	HBW, HBO, NHB
Paratransit services	High	Medium	Medium	HBW, HBO, NHB
Bus traffic signal preemption	Medium	Medium	Low	HBW, HBO
Joint development activities	Medium	Medium	Medium	HBW, HBO, NHB
Peak/off-peak transit fares	Medium	Low	Medium	HBW
Simplified fare collection	Medium	Medium	Medium	HBW, HBO, NHB
Reduced fares	High	Low	Medium	HBW, HBO, NHB
Vehicle Limitations/Restrictions				
Auto restricted zones	Medium	Medium	Medium	HBW

Source: Barnardin, Lochmueller & Associates, 1993.

Appendix B: Congestion Reduction Packages

Table B1 Components of Recommended Congestion Reduction Packages

Individual Techniques	Packages: Work Hours Changes	Pricing Techniques	Restricting Access	Land Use Changes	Ride Sharing	Tele-Commuting	Traffic Engineering Techniques	Transit Improvements
Staggered Work Hours	*	+					+	+
Parking Controls	*	*	+	+	*	*	+	+
Traffic Cells			*	+				+
Auto Free Zones			*	+				+
New Towns		+		*		*	+	
Planned Neighborhoods		+	+	*			+	
Zoning and Building Codes		+	+	*	+	+	+	+
Incentives to Transit Use	*	*	+	+				*
Carpooling/Ridesharing		*			*		+	
Communications in Lieu of Travel	+	+		+		+		
Freeway Surveillance and Control			+				*	
Maximising Use of Existing Facilities			*	+			*	
Transit Circulation	+	*	*	+	+			*
Priority Transit Arterials	+	*	+					*
Priority Transit Expressways	+	*	+					*
Extended Area Transit	*	*	+	+				*

* Component of basic package
\+ Supportive technique

Source: TRB, 1979.

Appendix C: Questionnaire on Data Collection and System Monitoring

QUESTIONNAIRE ON DATA COLLECTION AND SYSTEM MONITORING

Agency:...

Counties in jurisdiction:...................................

....

Name of Official(s):..

Please check all types of data being collected in your area.

Highway Data:

* Road Miles
  - By functional classification [ ]
  - By geographical area [ ]
* Lane Miles of Arterials During Peak Period
  - By functional classification of arterials [ ]
  - By number of lanes [ ]
  - By geographical area [ ]
  - By one-way or two-way direction [ ]
* Miles of reversible lanes [ ]
* Vehicle Miles of Travel
  - By functional classification [ ]
  - By geographic area [ ]
  - By vehicle type [ ]
* Passenger Miles of Travel
  - By functional classification [ ]
  - By geographic area [ ]
  - By vehicle type [ ]
* Average Speed
  - By functional classification [ ]
  - By geographic area [ ]
  - By vehicle type [ ]
* CBD cordon measurement
  - Passenger occupancy [ ]
  - Vehicle type [ ]
* Traffic Volume and Congestion
  - Number of hours with v/c > x [ ]
  - % VMT with v/c > x [ ]
  - % PMT with v/c > x [ ]
  - VMT with LOS > X [ ]
  - Lane Miles with LOS > X [ ]
  - LOS for links [ ]

LOS for intersections [ ]
Delay on links [ ]
Delay at intersections [ ]
Incident duration [ ]
Delay due to construction [ ]

Public Transit Data:

* Land area within 0.25 mile of weekday transit service [ ]
* Total system miles [ ]
    * Total route miles [ ]
* Annual unlinked passenger trips [ ]
* Annual passengers [ ]
* Annual vehicle miles [ ]

Demographic Data:

* Population
    By geographic area [ ]
* Dwelling Units
    By geographic area [ ]
* Employment
    By geographic area [ ]
    By CBD [ ]
* Passenger Vehicle Registrations
    By county [ ]
    By vehicle type [ ]
* Land Areas
    By urbanized area [ ]
    By central city [ ]
    By central business district [ ]
    By federal-aid system boundaries [ ]

Other Data:
Please specify:

If LOS is used as a performance measure, please indicate what it is based on (avg. speed, avg. delay, v/c ratio, etc.)?

How often is data collected?

What are your costs involved with data collection?

What problems, if any, do you have with respect to data collection?

Goods Movement:
Are rail freight facilities available in your area? Y[ ]N[ ]
Are there major trucking terminals located in your area?
Y[ ] N[ ]

Highways:
Identify most significant State routes:

Identify most significant Municipal routes:

List any other significant routes, either State or local:

Congestion:
What is your area's threshold for congestion?

How do you identify and quantify congestion - recurring and non-recurring?

<u>Problem Areas:</u>
Please list your problem areas with respect to:

Congestion - when (what hours of the day), where (geographic extent) and how (bottlenecks, weaving, signal timing, too few lanes, etc.) does it occur?

Safety:

Other:

<u>Needs:</u>
Please list transportation improvement priorities:

Congestion Reduction Strategies:

List all congestion reduction strategies currently underway in your area:

What are your goals?

List all congestion reduction strategies being studied for future implementation:

What will be your goals?

Appendix D: Daily and Seasonal Variations of 'K' and 'D' Factors

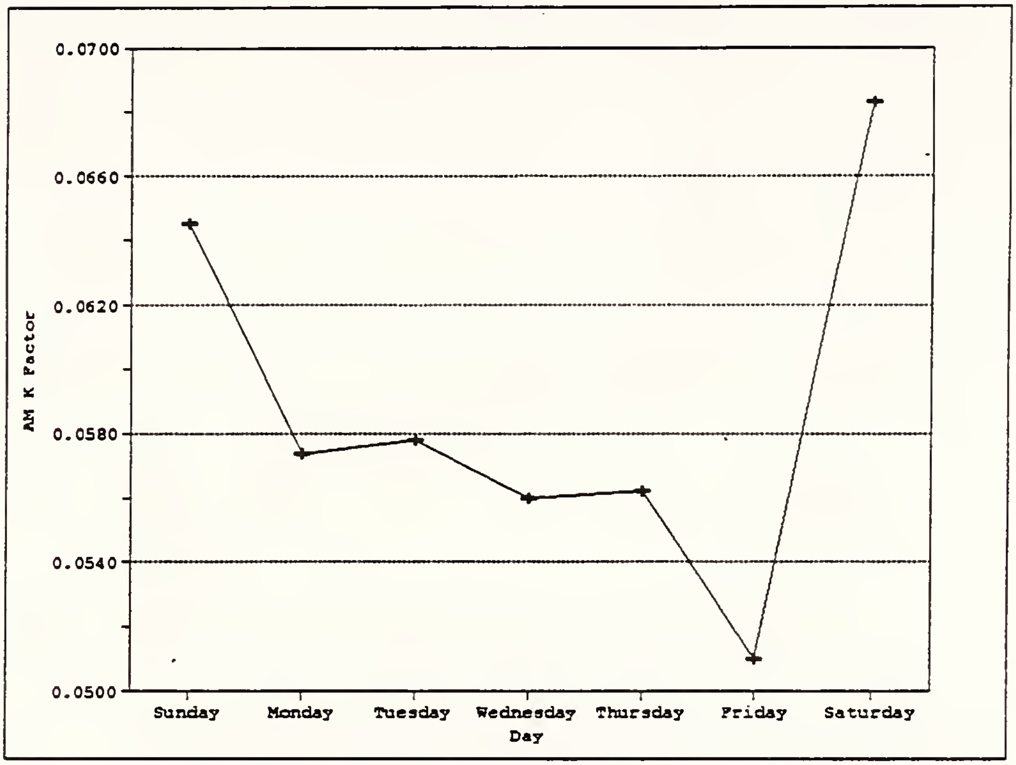

Figure D1 Average Variations of AM 'K' Factor by Day of Week for Urban Freeway/Interstate

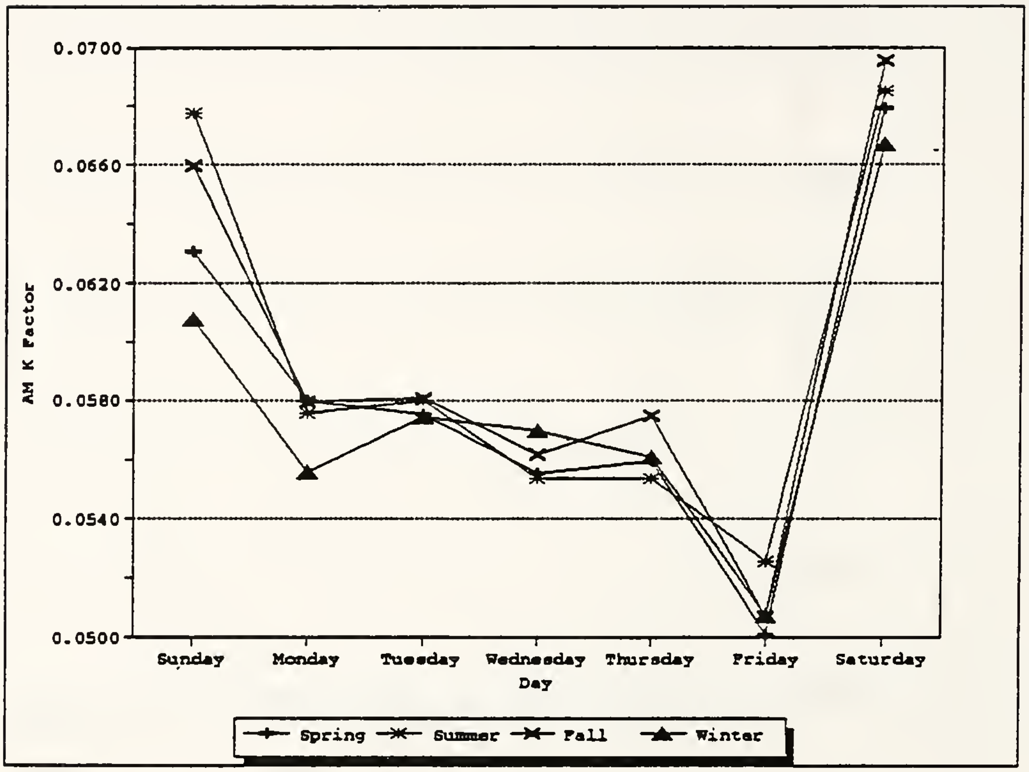

Figure D2 Average Variations of AM 'K' Factor by Day of Season for Urban Freeway/Interstate

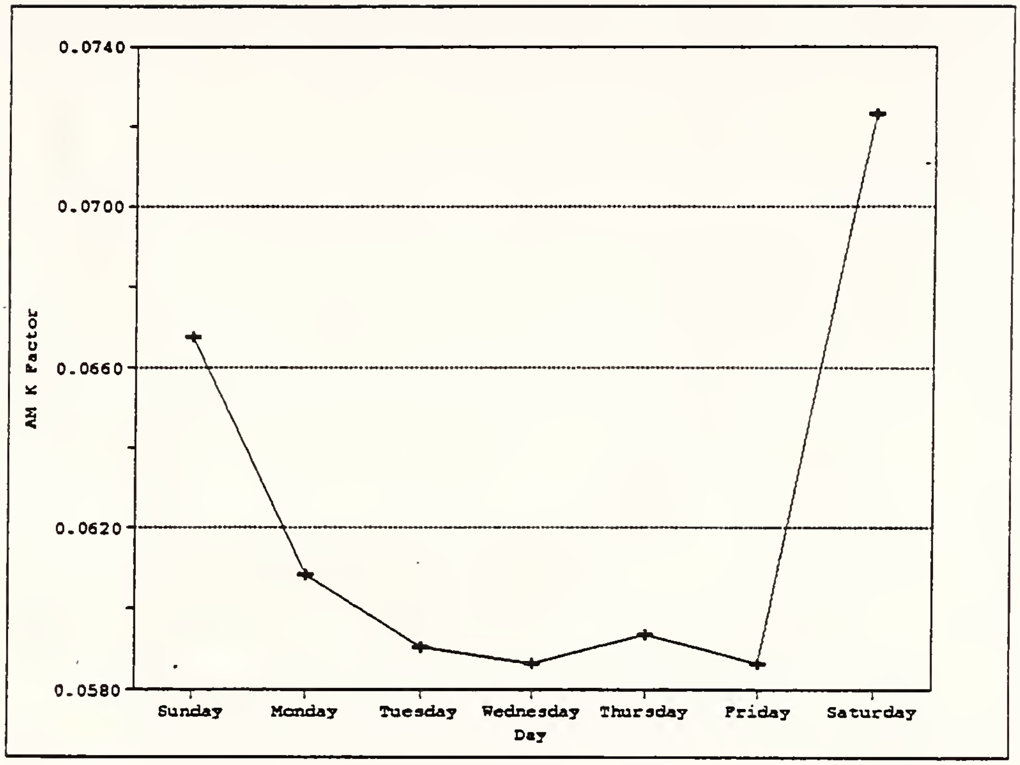

Figure D3 Average Variations of AM 'K' Factor by Day of Week for Urban Arterial

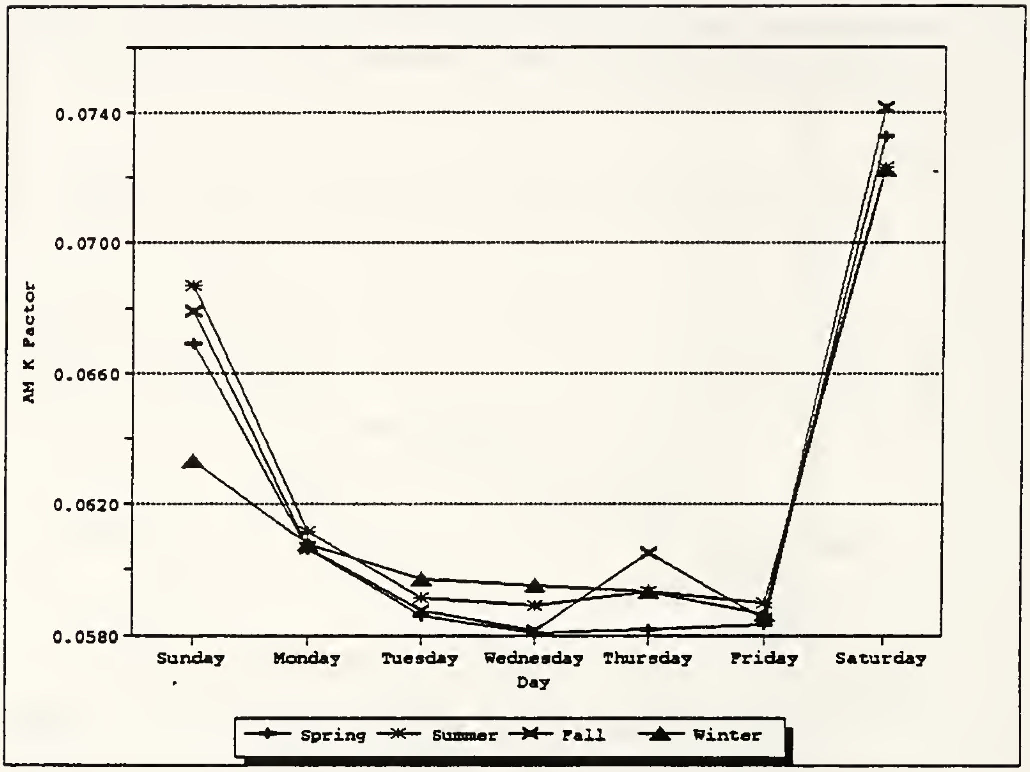

Figure D4 Average Variations of AM 'K' Factor by Day of Season for Urban Arterial

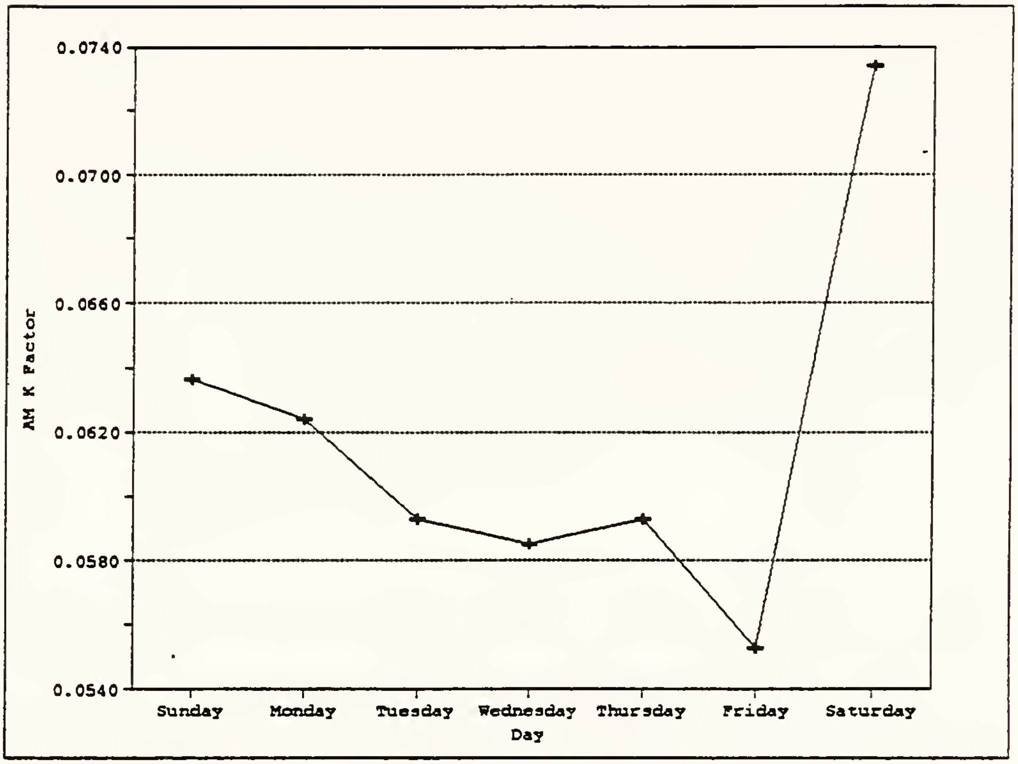

Figure D5 Average Variations of AM 'K' Factor by Day of Week for Rural Interstate

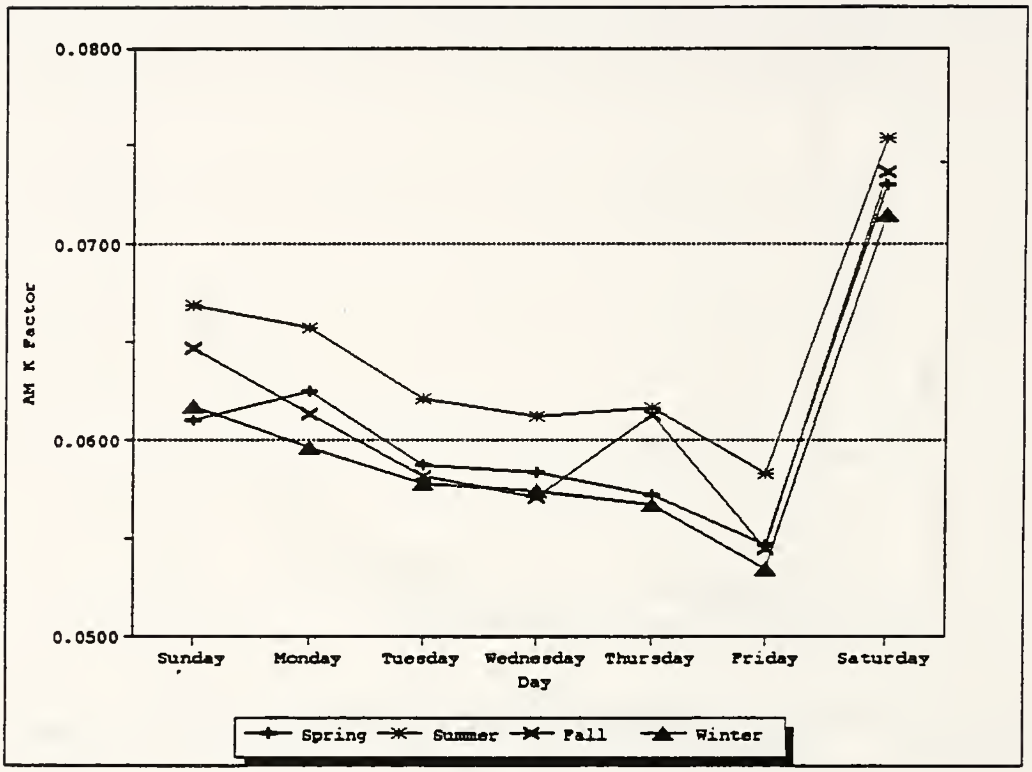

Figure D6 Average Variations of AM 'K' Factor by Day of Season for Rural Interstate

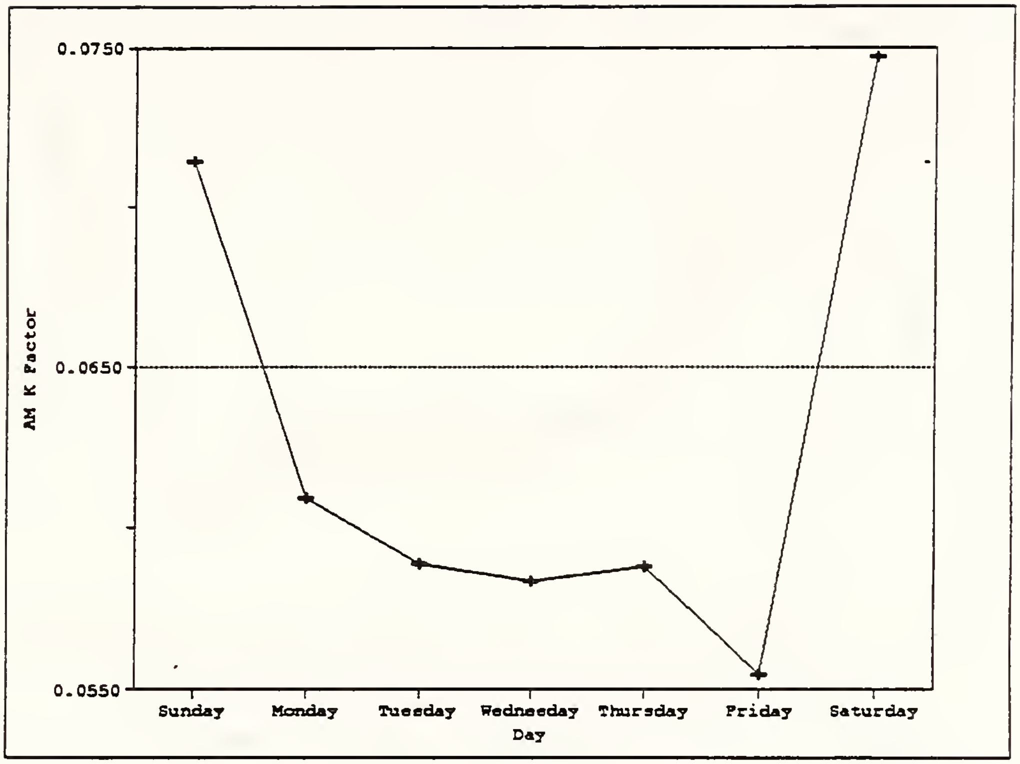

Figure D7 Average Variations of AM 'K' Factor by Day of Week for Rural Arterial

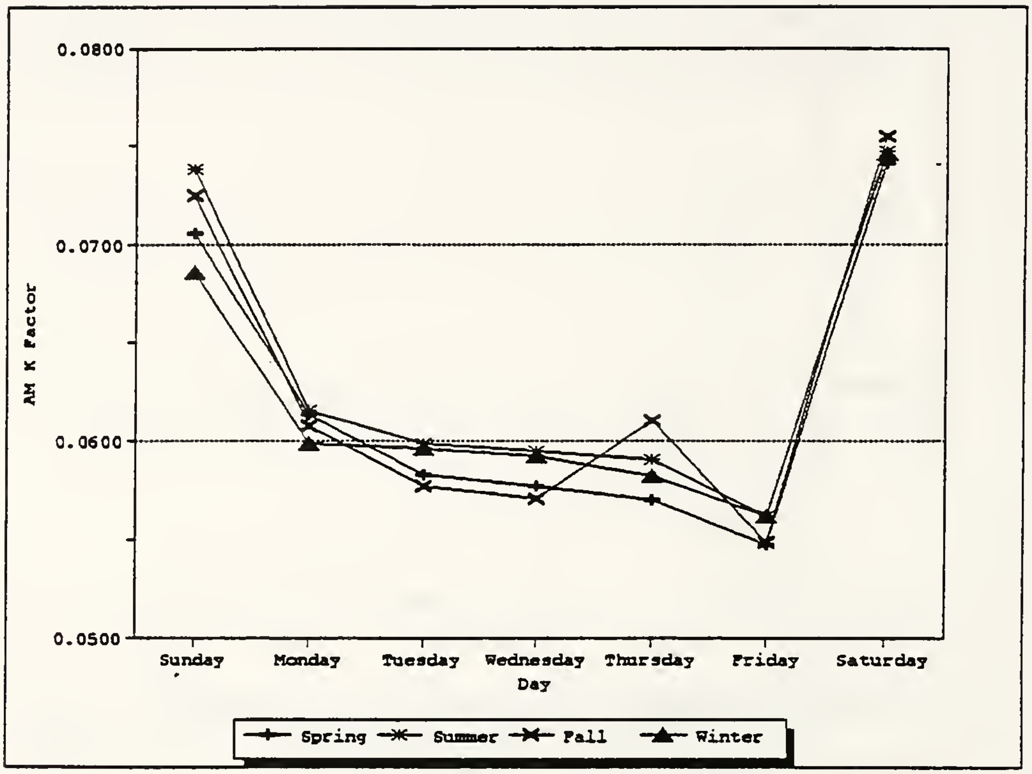

Figure D8 Average Variations of AM 'K' Factor by Day of Season for Rural Arterial

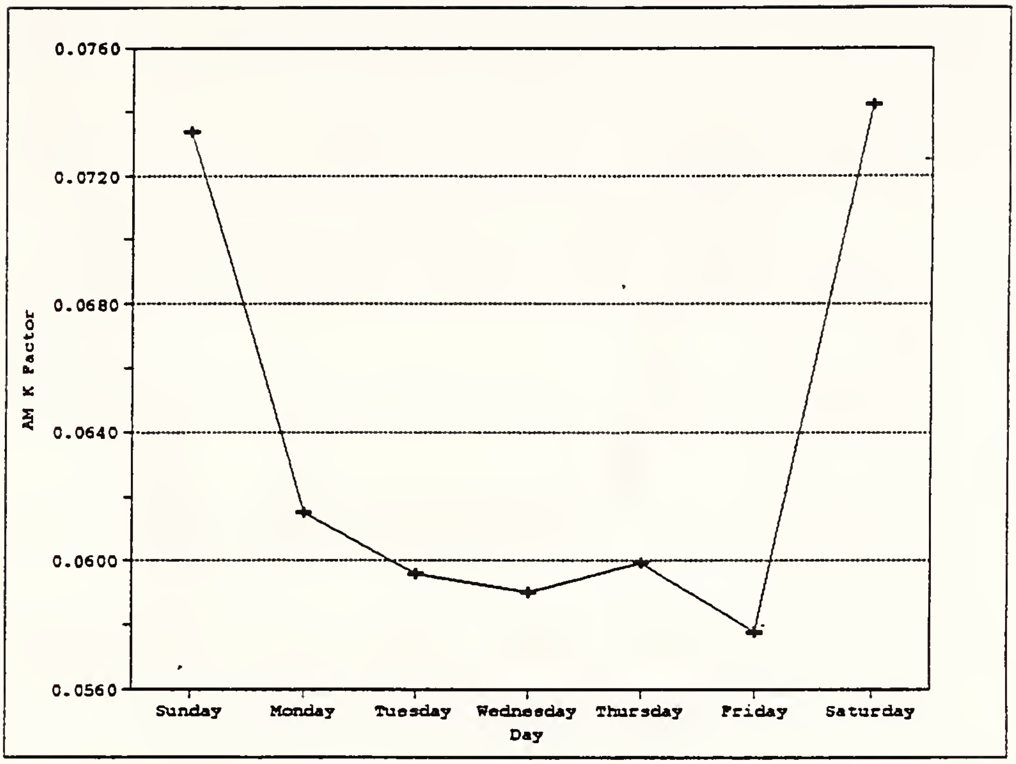

Figure D9 Average Variations of AM 'K' Factor by Day of Week for Rural Collector

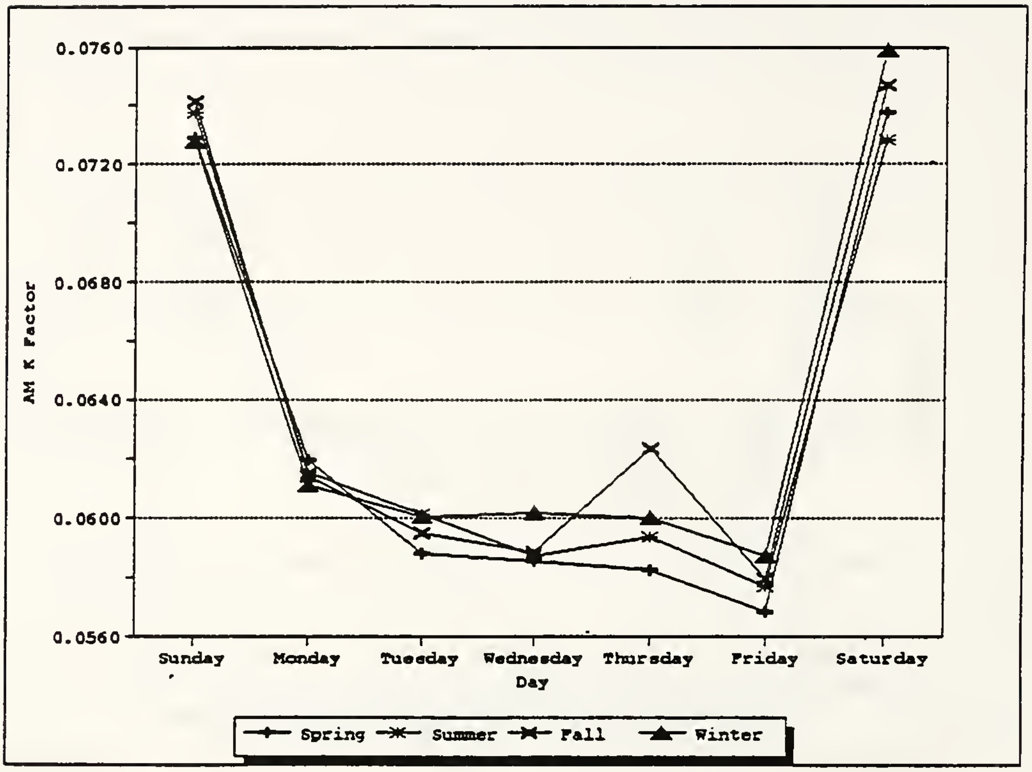

Figure D10 Average Variations of AM 'K' Factor by Day of Season for Rural Collector

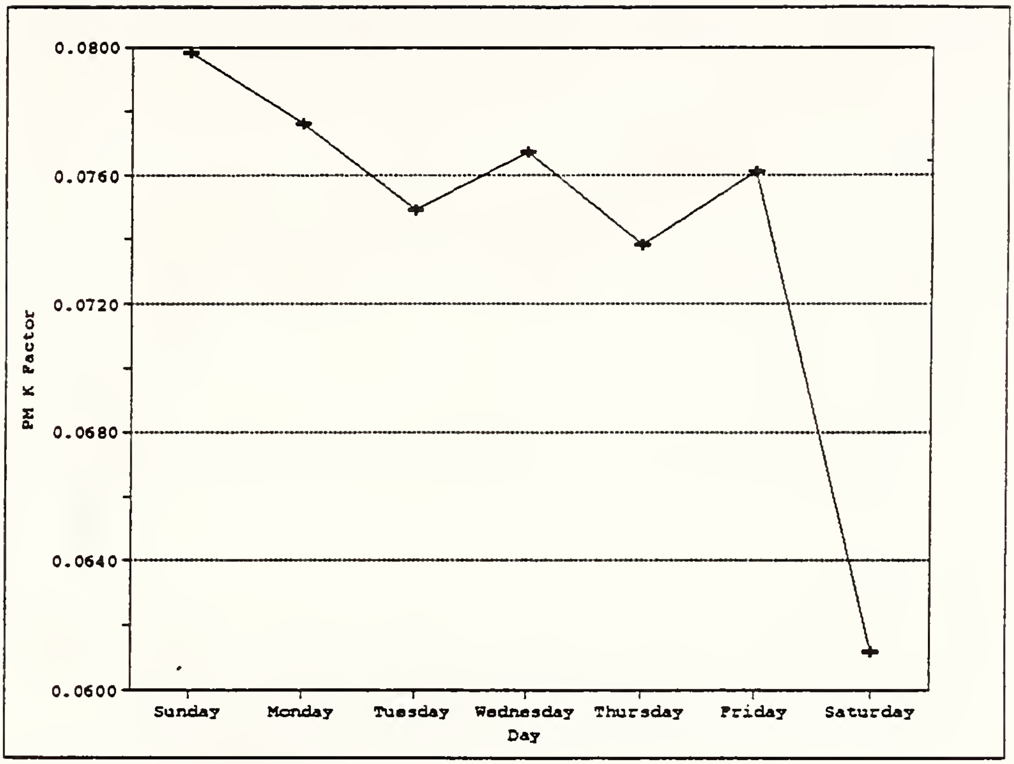

Figure D11 Average Variations of PM 'K' Factor by Day of Week for Urban Freeway/Interstate

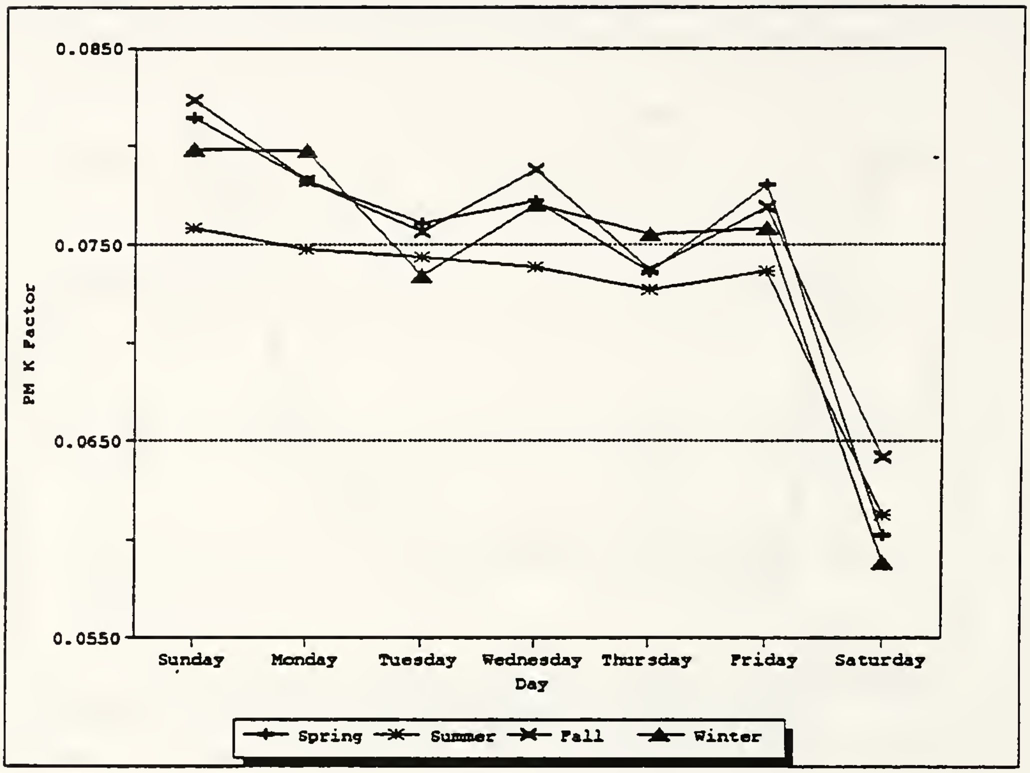

Figure D12 Average Variations of PM 'K' Factor by Day of Season for Urban Freeway/Interstate

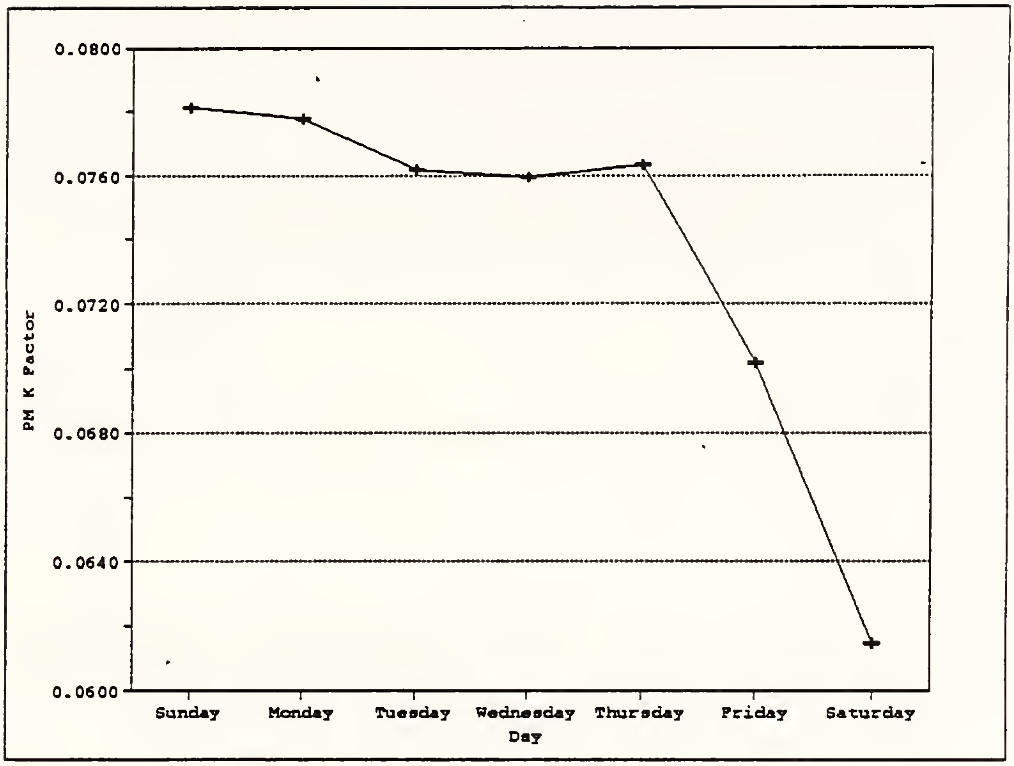

Figure D13 Average Variations of PM 'K' Factor by Day of Week for Urban Arterial

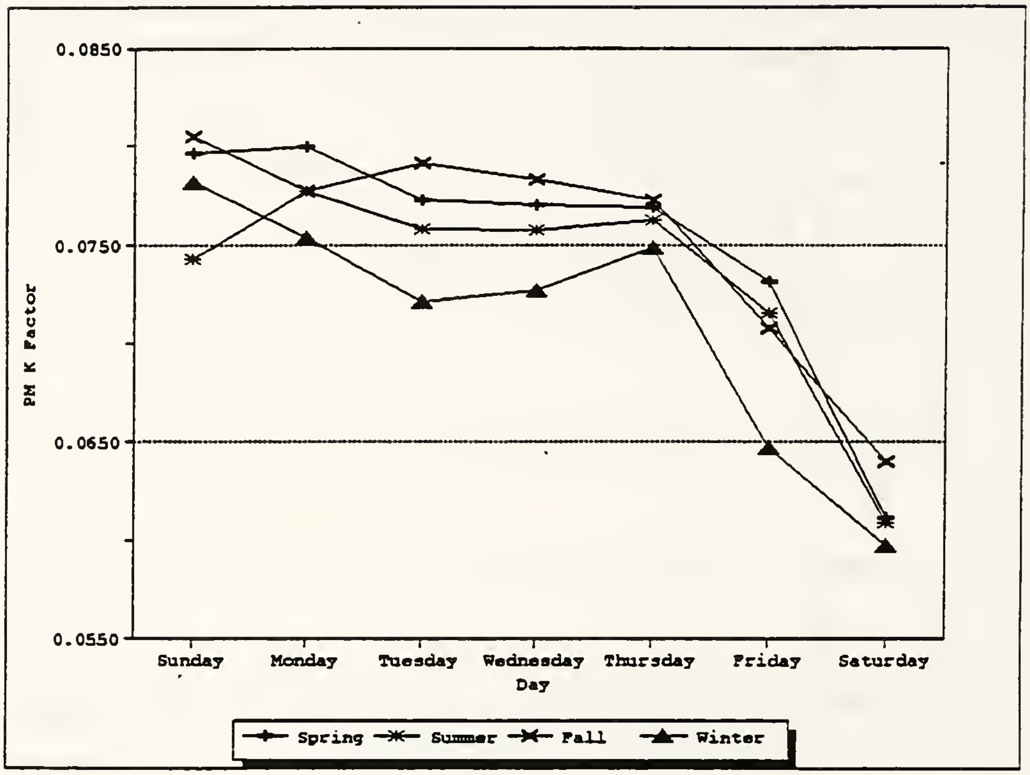

Figure D14 Average Variations of PM 'K' Factor by Day of Season for Urban Arterial

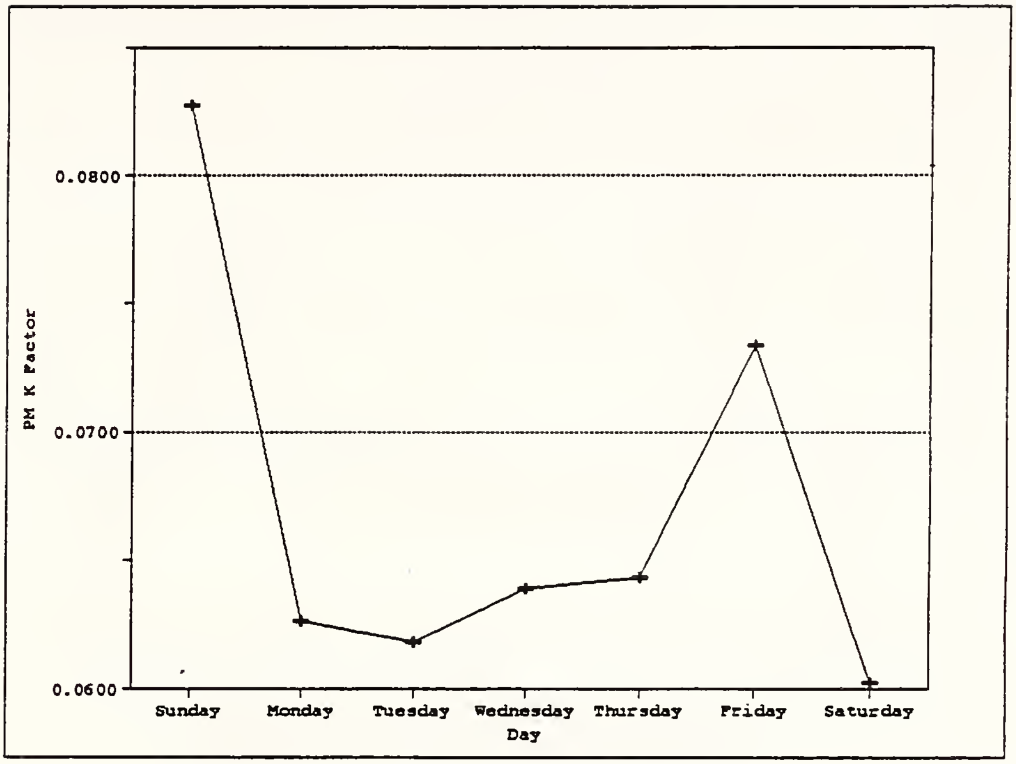

Figure D15 Average Variations of PM 'K' Factor by Day of Week for Rural Interstate

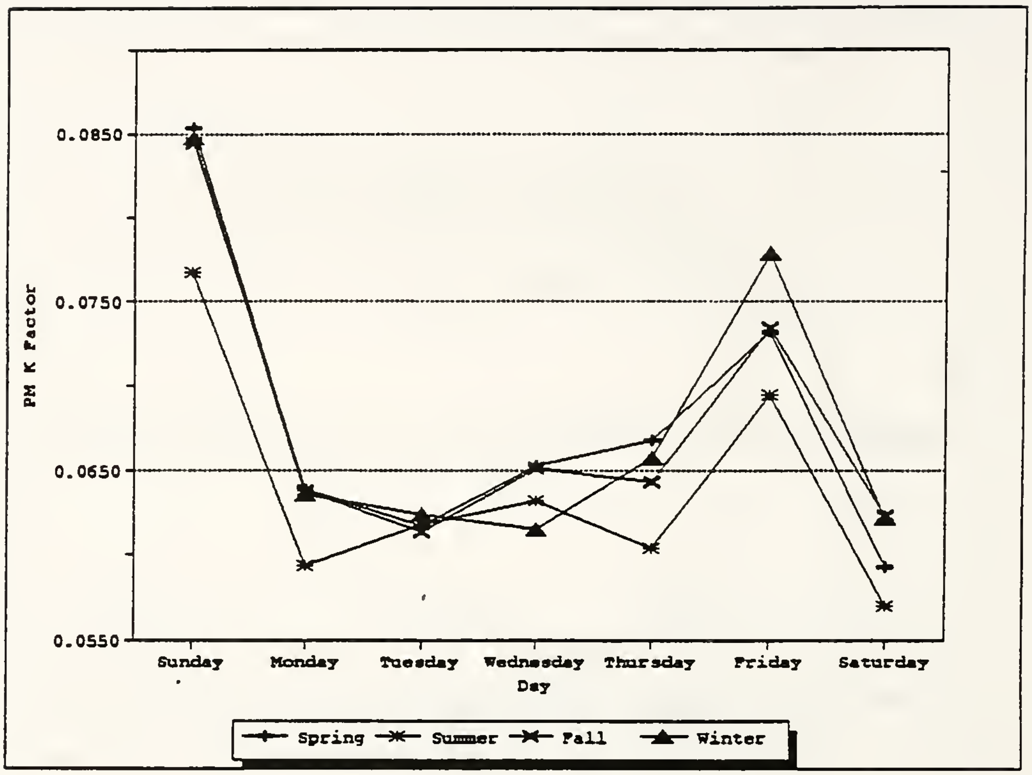

Figure D16 Average Variations of PM 'K' Factor by Day of Season for Rural Interstate

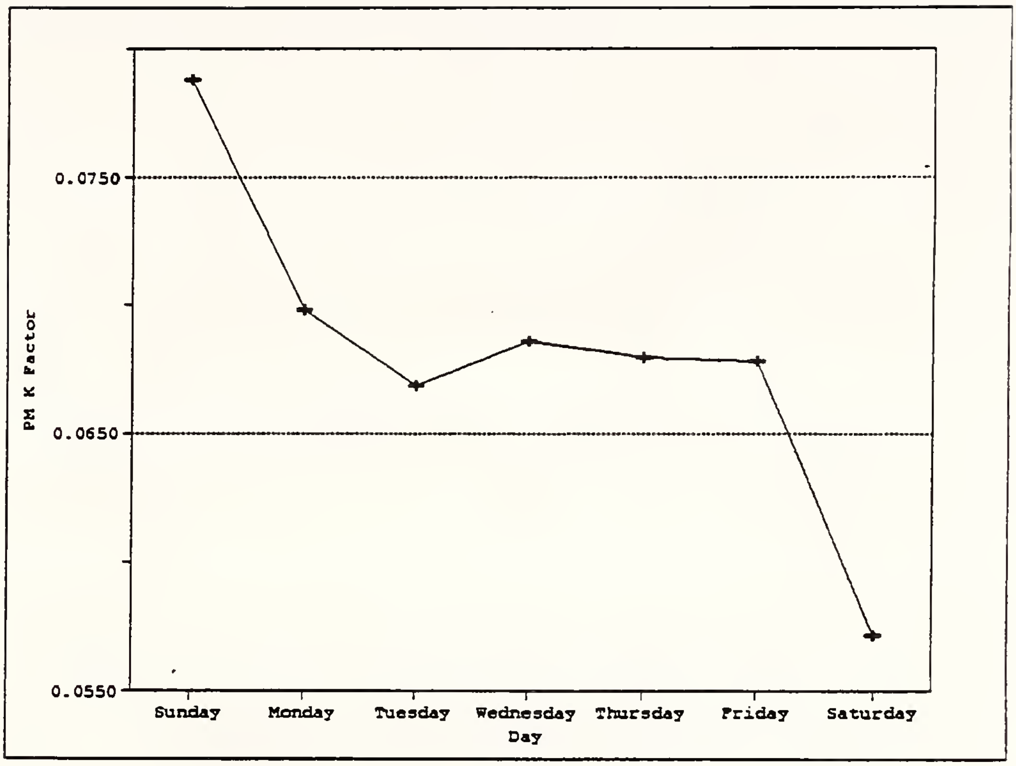

Figure D17 Average Variations of PM 'K' Factor by Day of Week for Rural Arterial

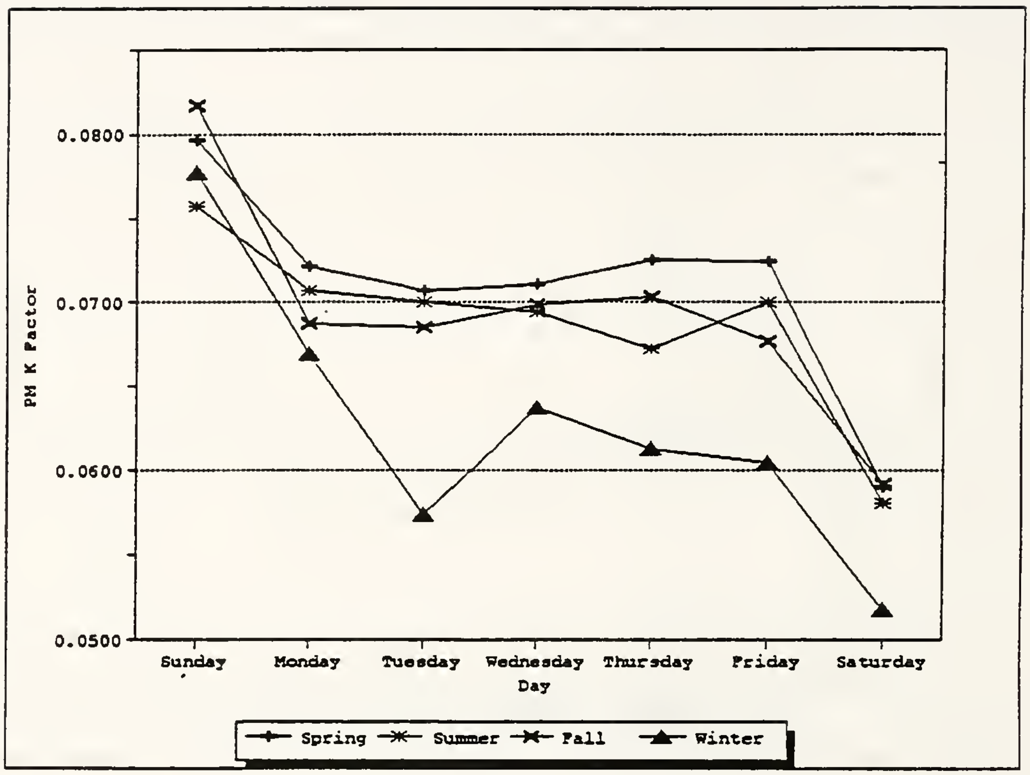

Figure D18 Average Variations of PM 'K' Factor by Day of Season for Rural Arterial

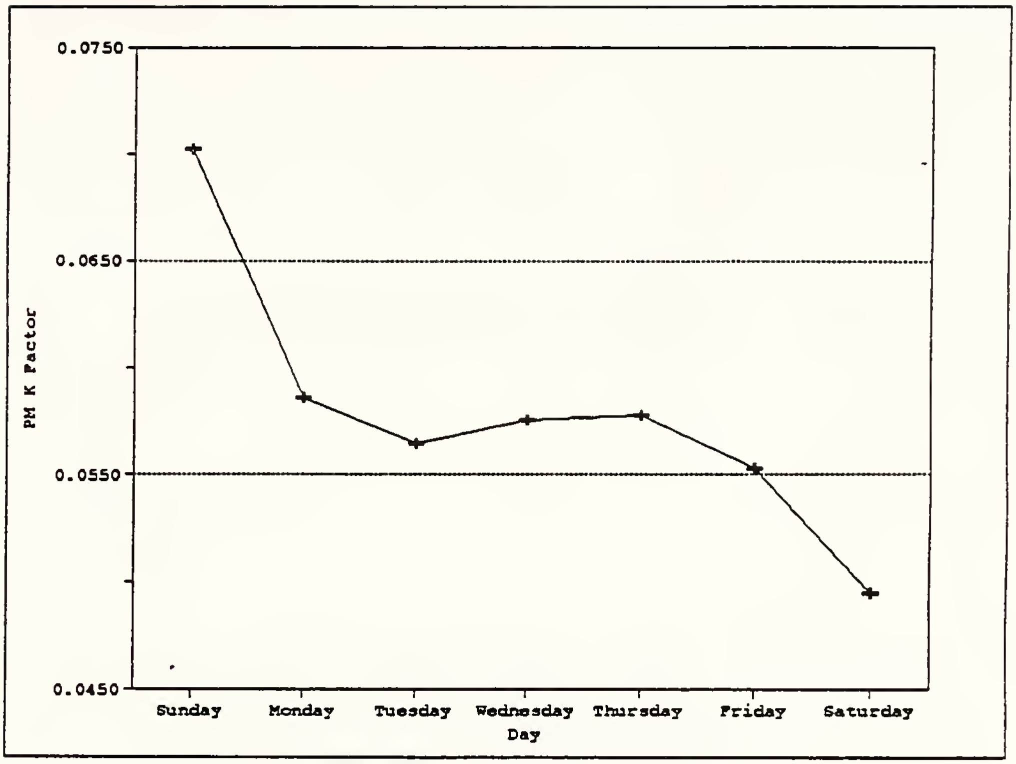

Figure D19 Average Variations of PM 'K' Factor by Day of Week for Rural Collector

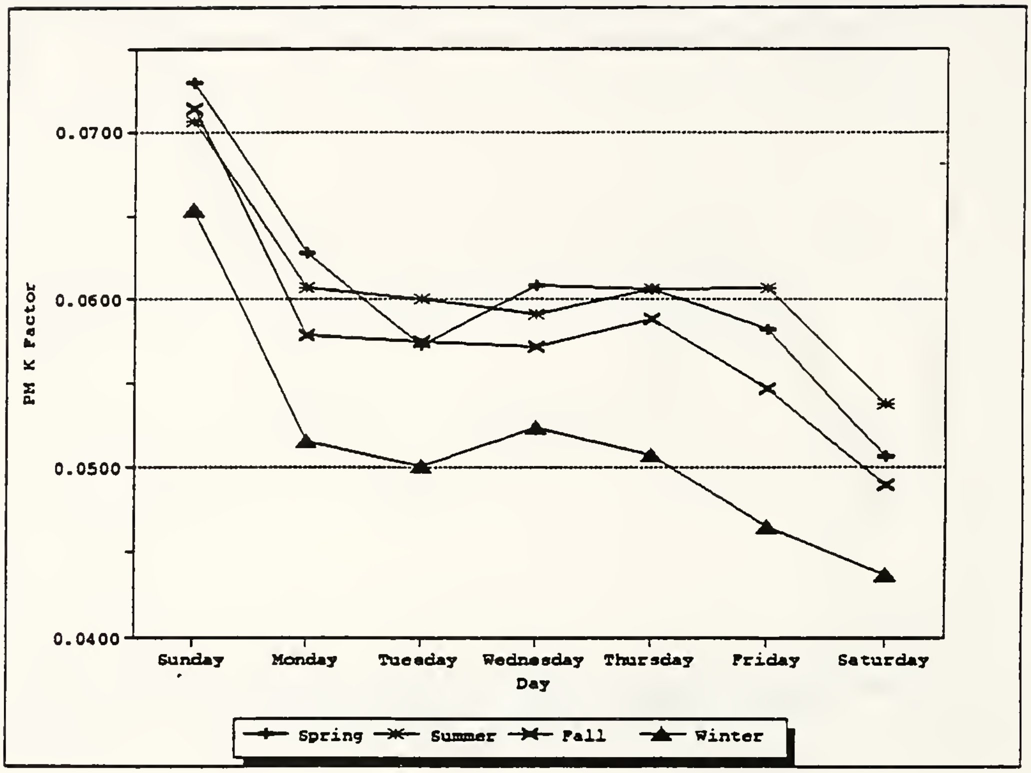

Figure D20 Average Variations of PM 'K' Factor by Day of Season for Rural Collector

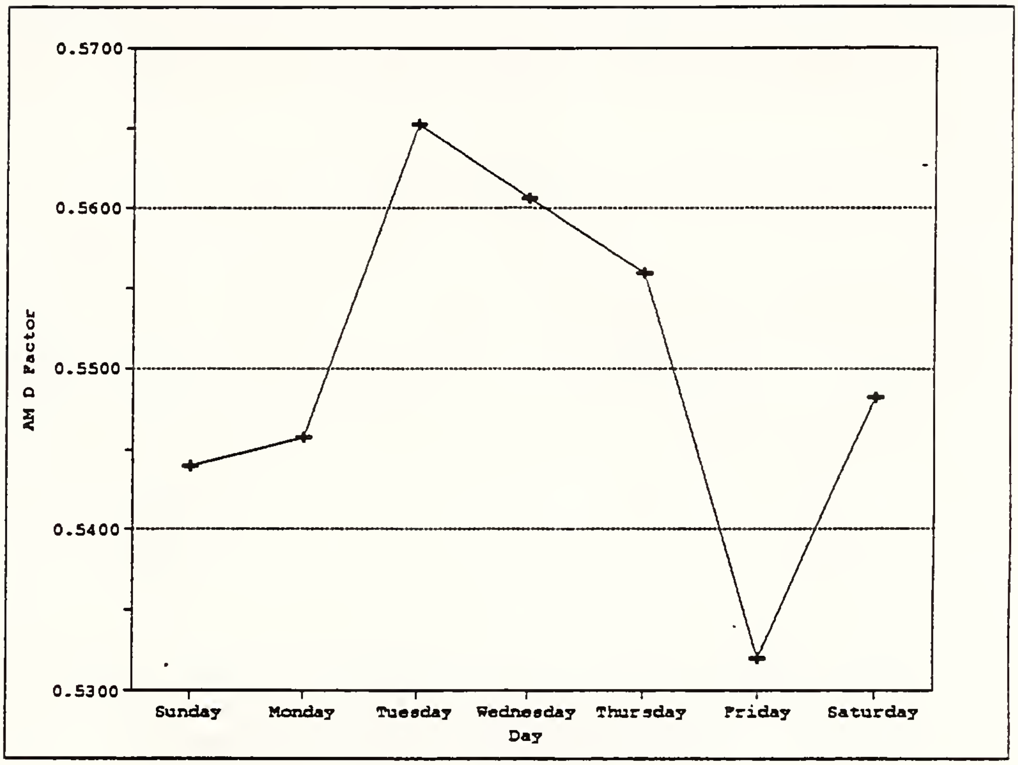

Figure D21 Average Variations of AM 'D' Factor by Day of Week for Urban Freeway/Interstate

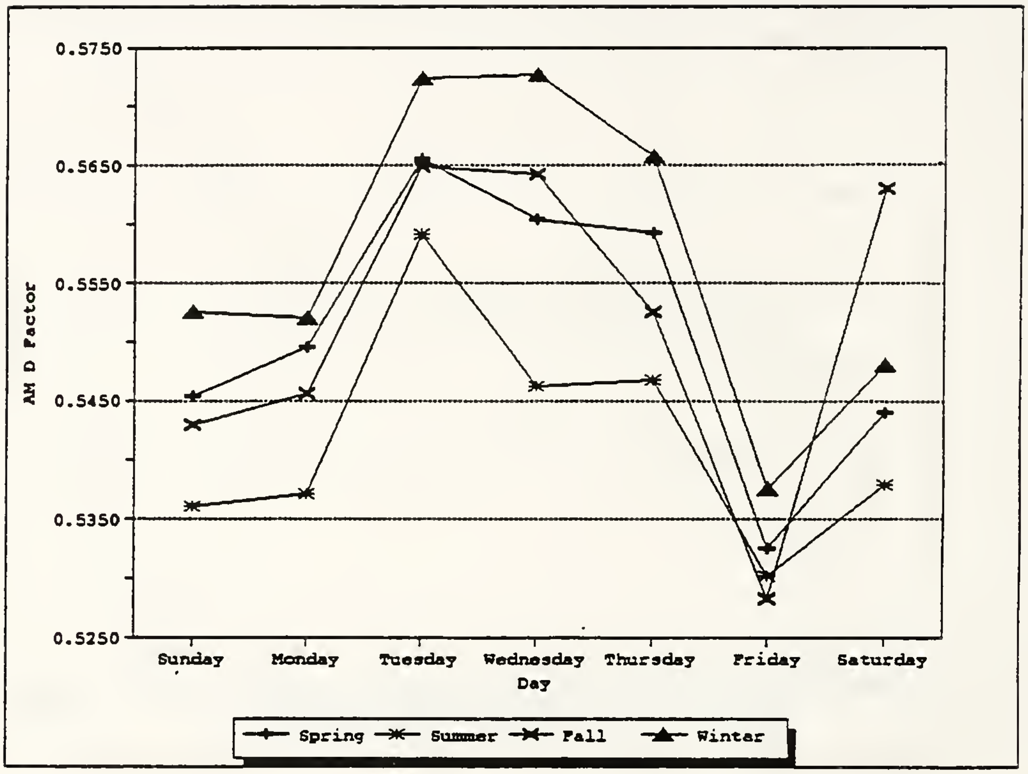

Figure D22 Average Variations of AM 'D' Factor by Day of Season for Urban Freeway/Interstate

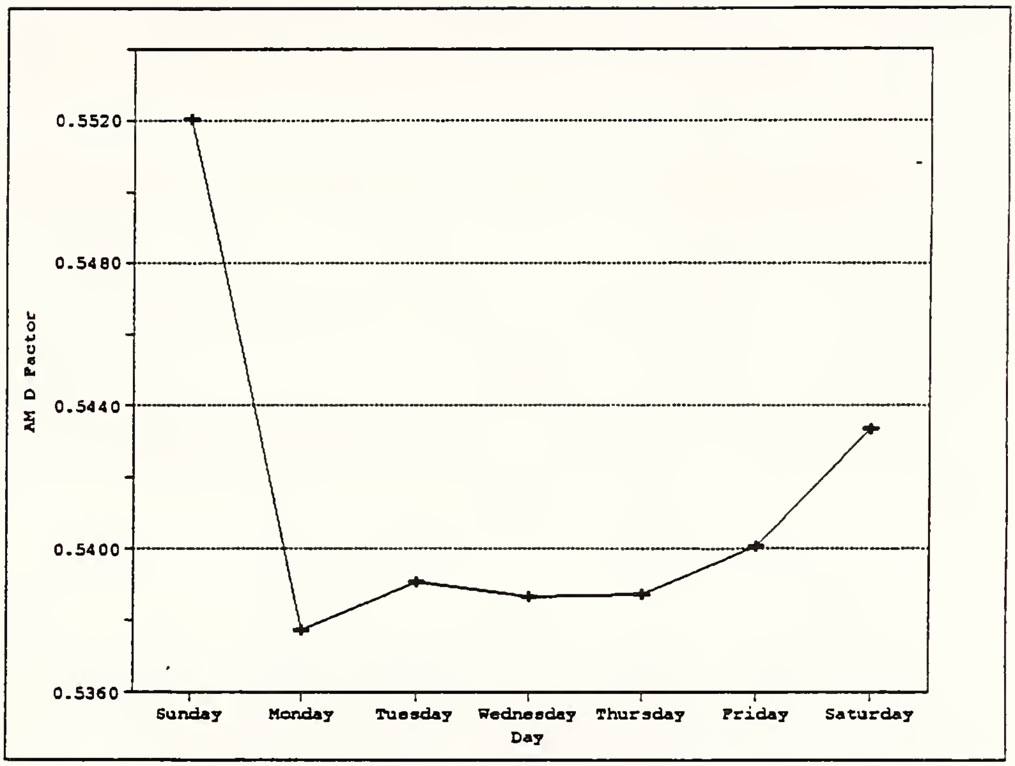

Figure D23 Average Variations of AM 'D' Factor by Day of Week for Urban Arterial

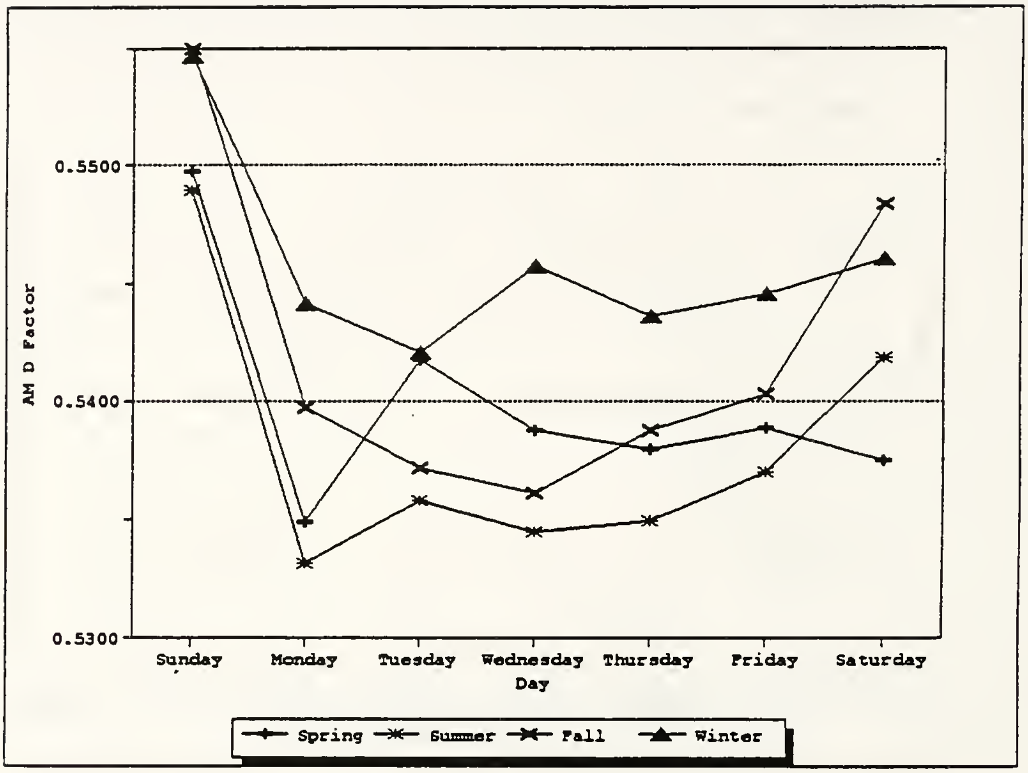

Figure D24 Average Variations of AM 'D' Factor by Day of Season for Urban Arterial

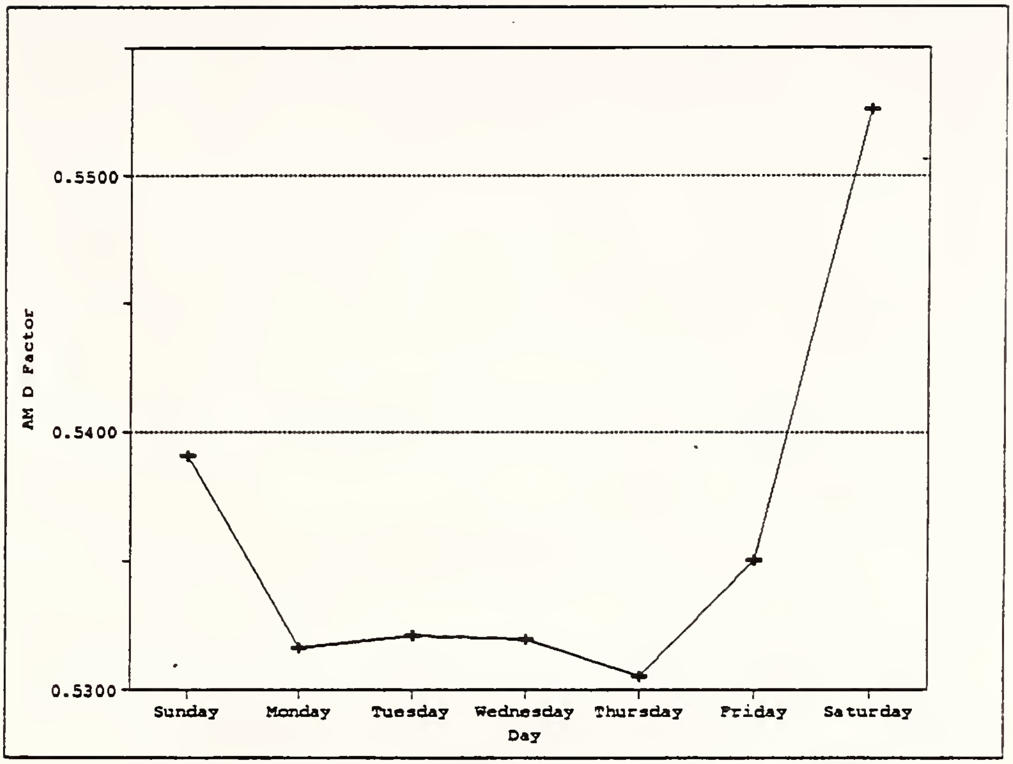

Figure D25 Average Variations of AM 'D' Factor by Day of Week for Rural Interstate

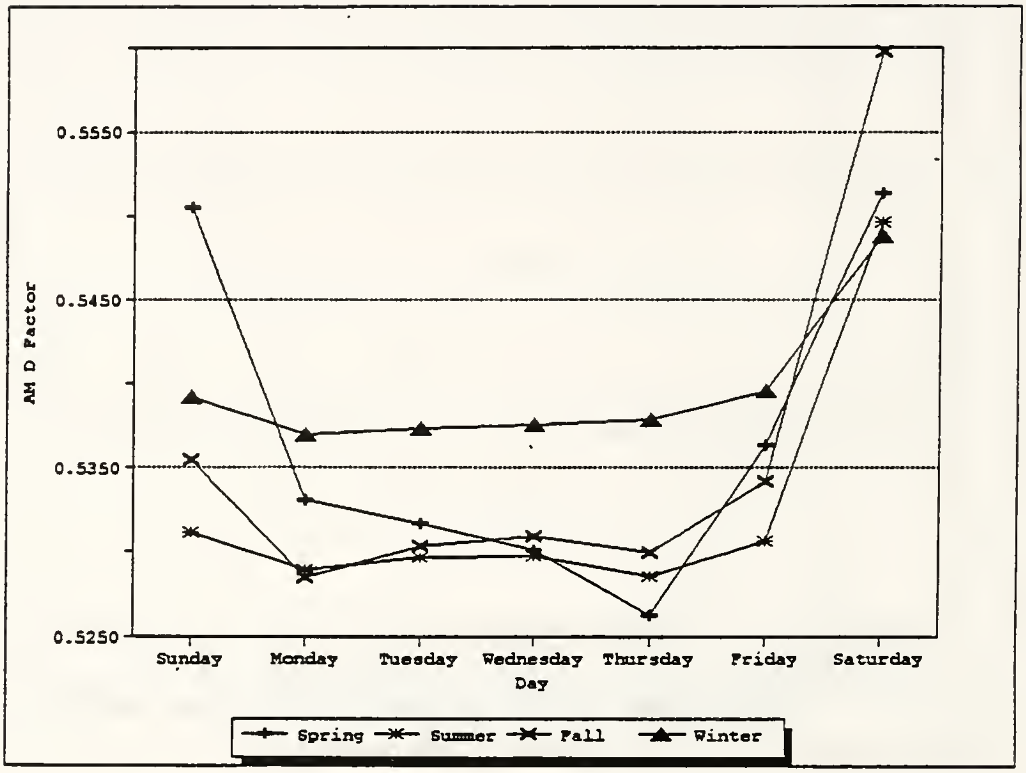

Figure D26 Average Variations of AM 'D' Factor by Day of Season for Rural Interstate

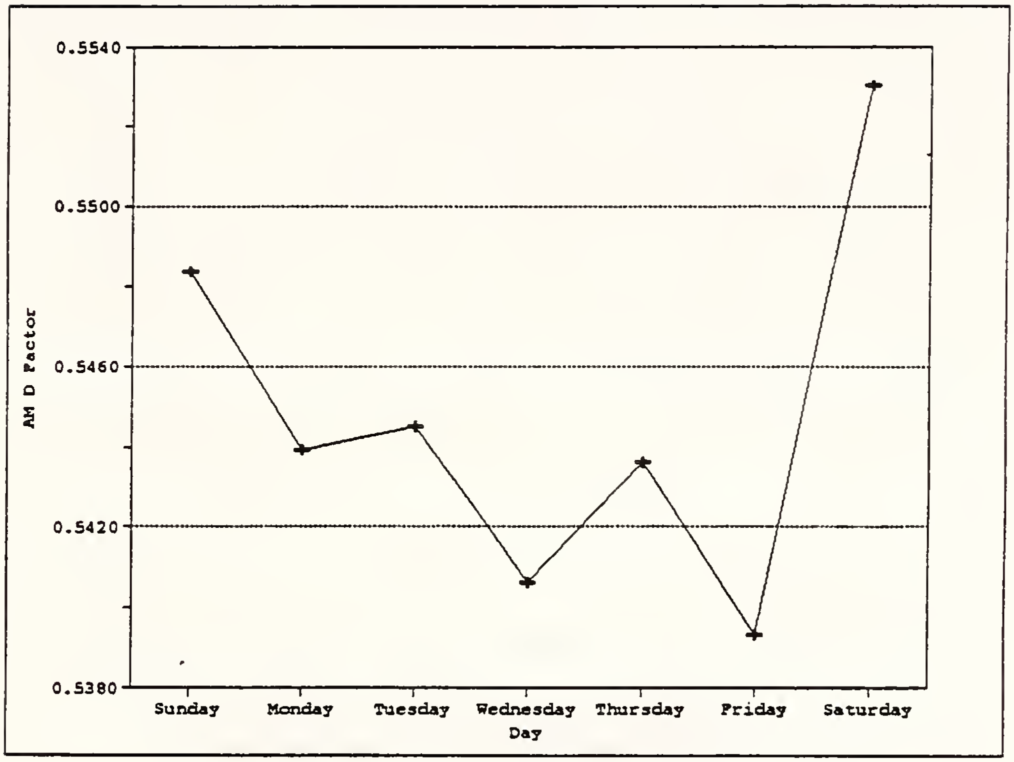

Figure D27 Average Variations of AM 'D' Factor by Day of Week for Rural Arterial

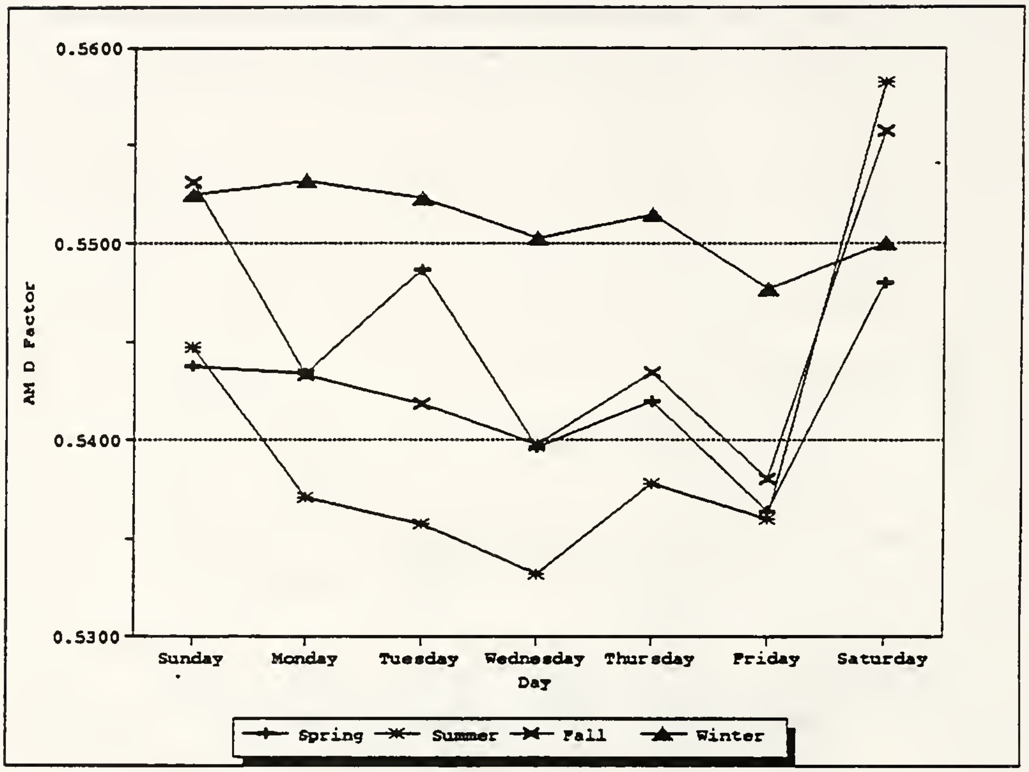

Figure D28 Average Variations of AM 'D' Factor by Day of Season for Rural Arterial

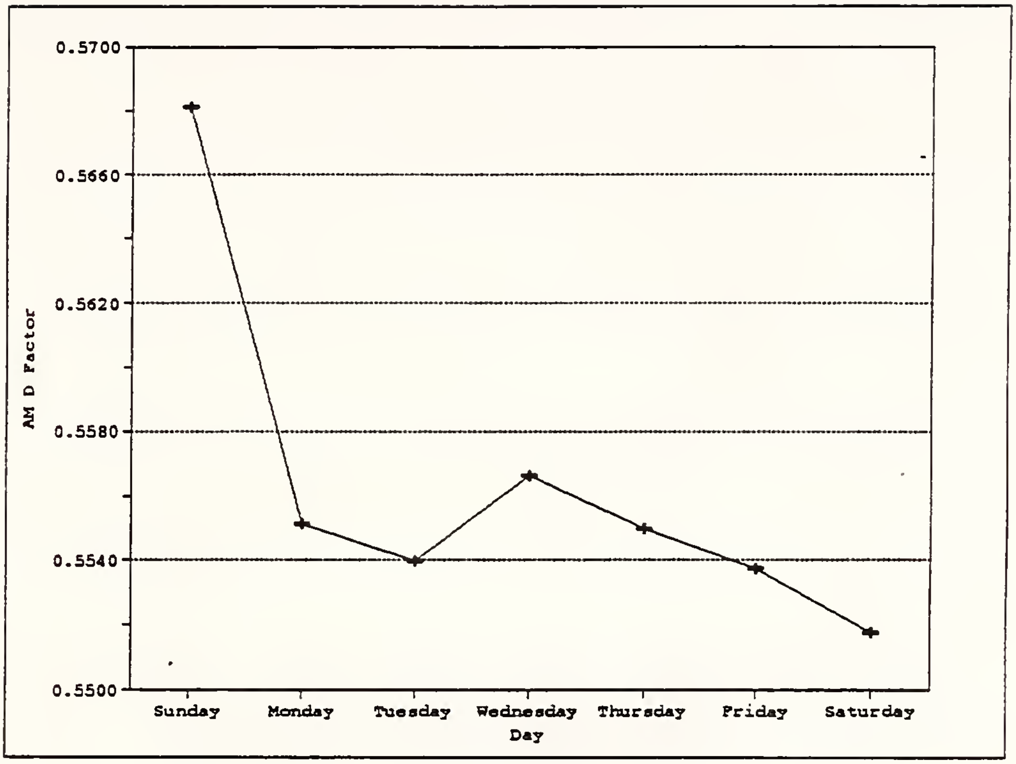

Figure D29 Average Variations of AM 'D' Factor by Day of Week for Rural Collector

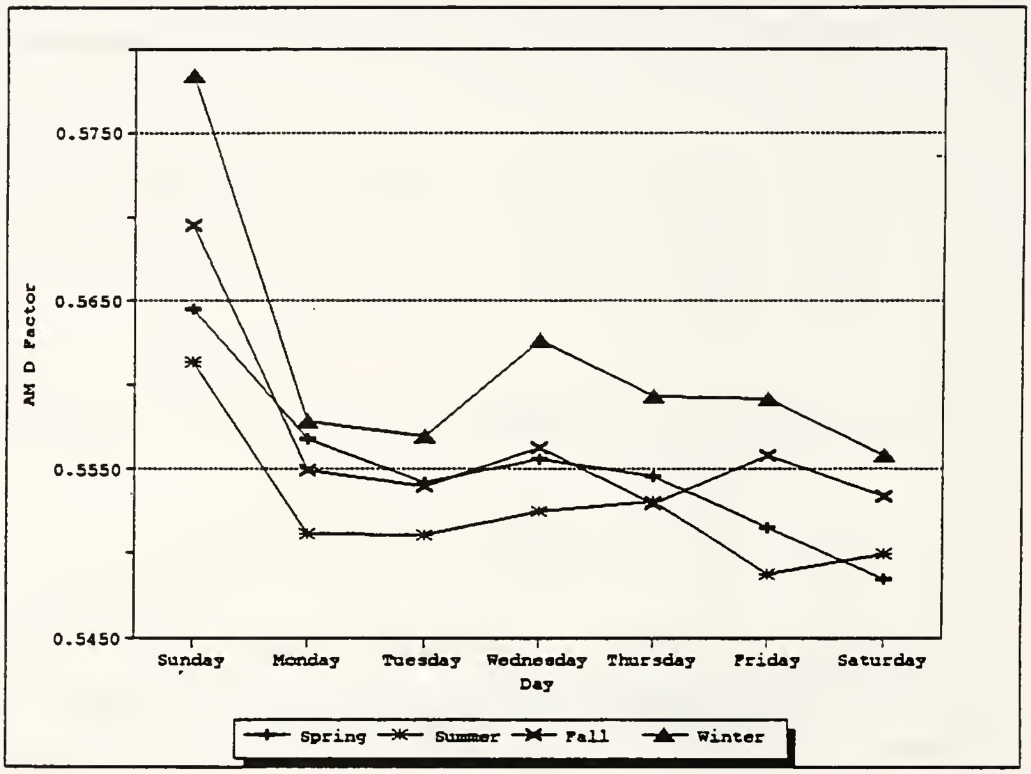

Figure D30 Average Variations of AM 'D' Factor by Day of Season for Rural Collector

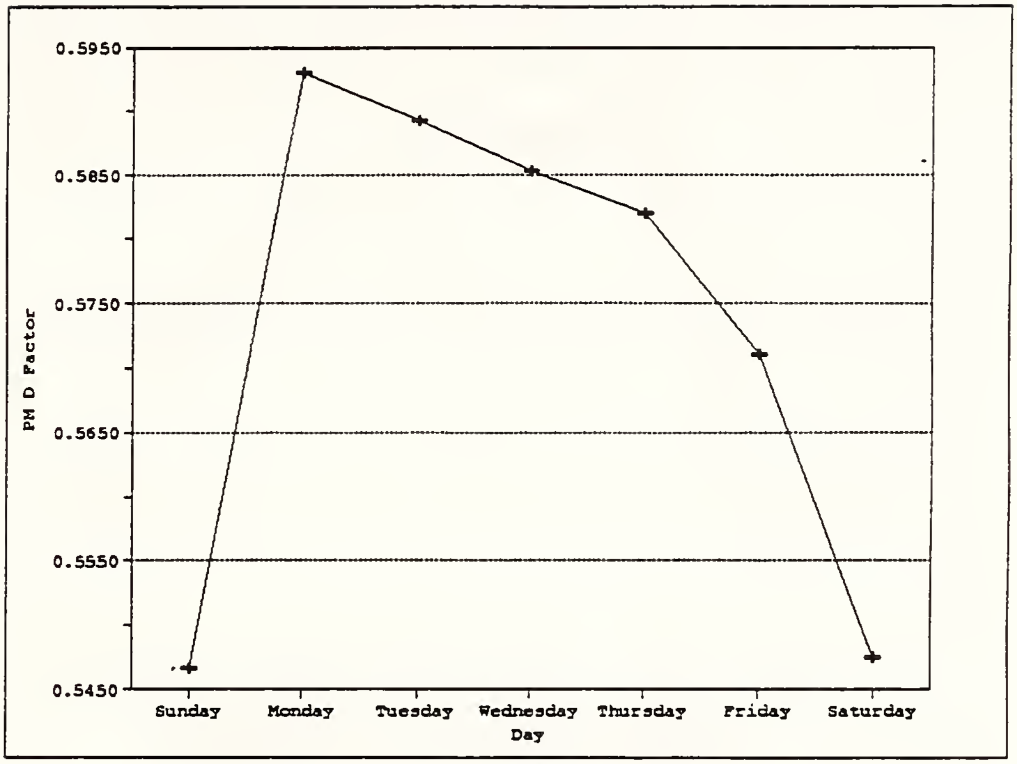

Figure D31 Average Variations of PM 'D' Factor by Day of Week for Urban Freeway/Interstate

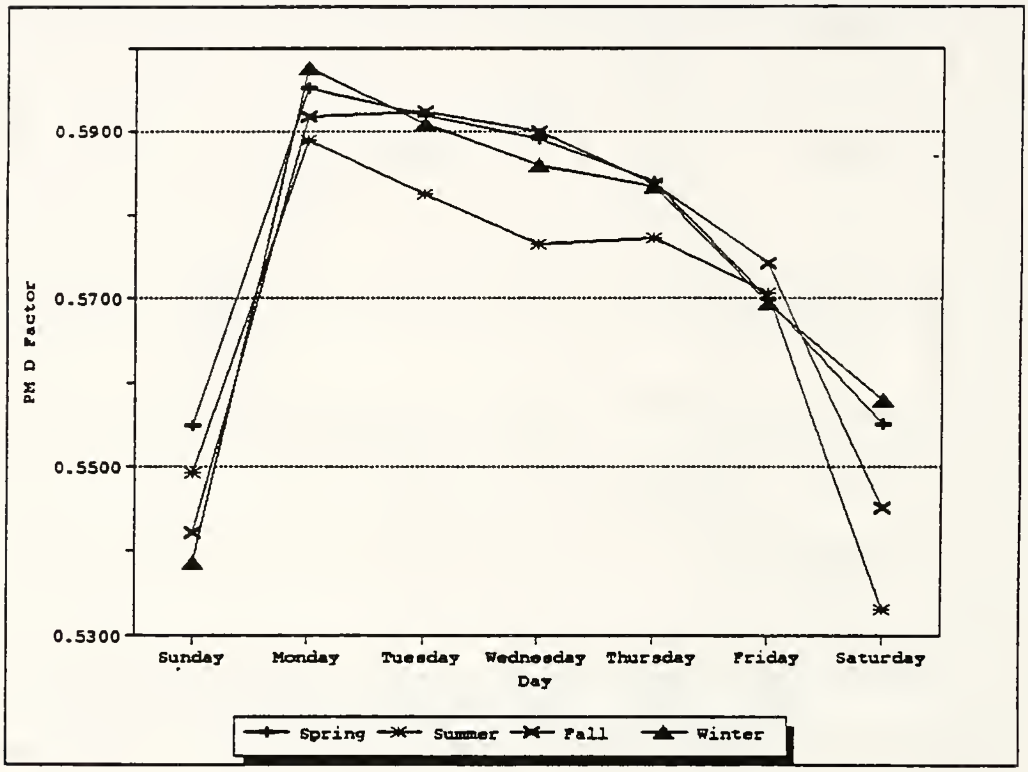

Figure D32 Average Variations of PM 'D' Factor by Day of Season for Urban Freeway/Interstate

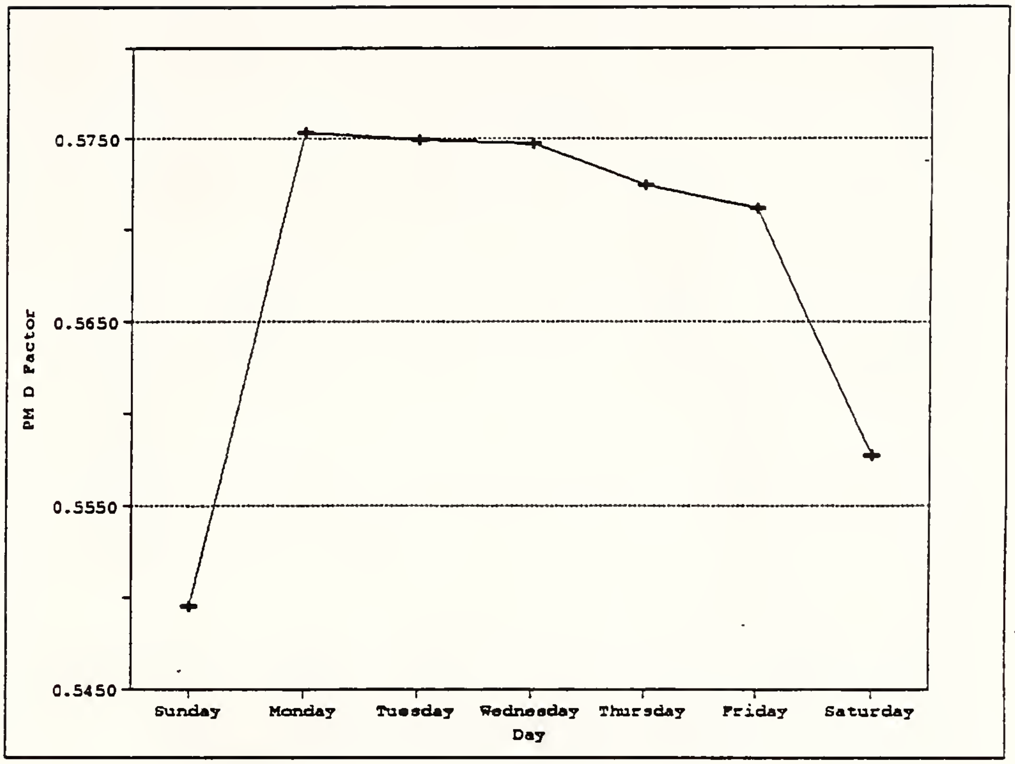

Figure D33 Average Variations of PM 'D' Factor by Day of Week for Urban Arterial

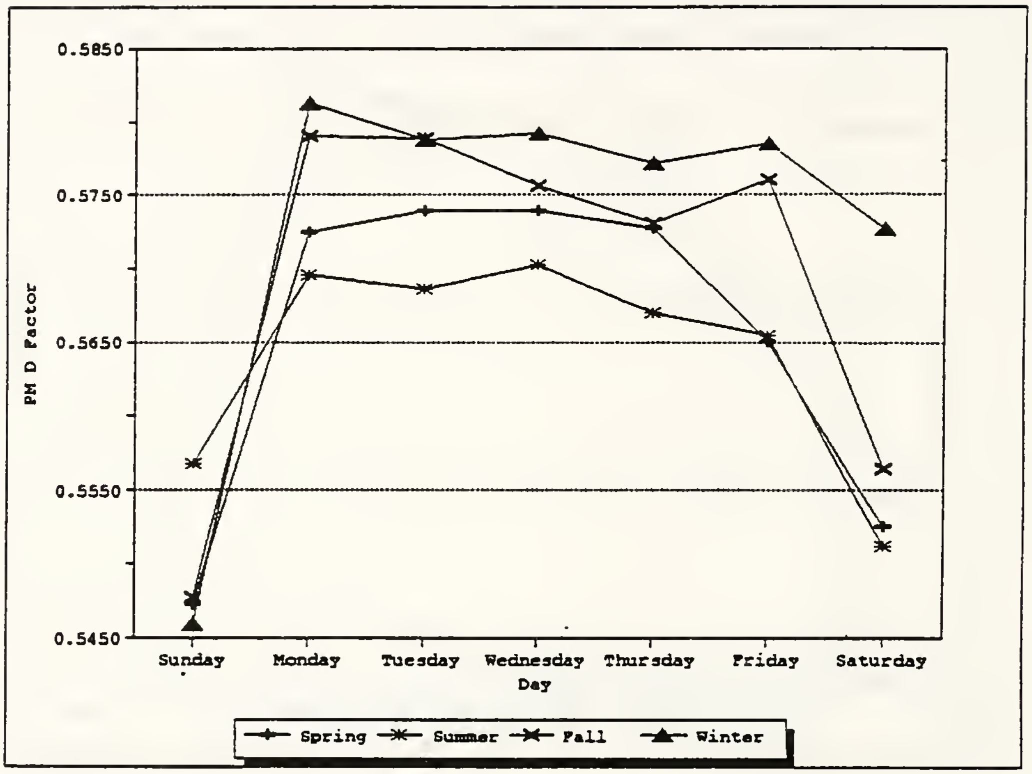

Figure D34 Average Variations of PM 'D' Factor by Day of Season for Urban Arterial

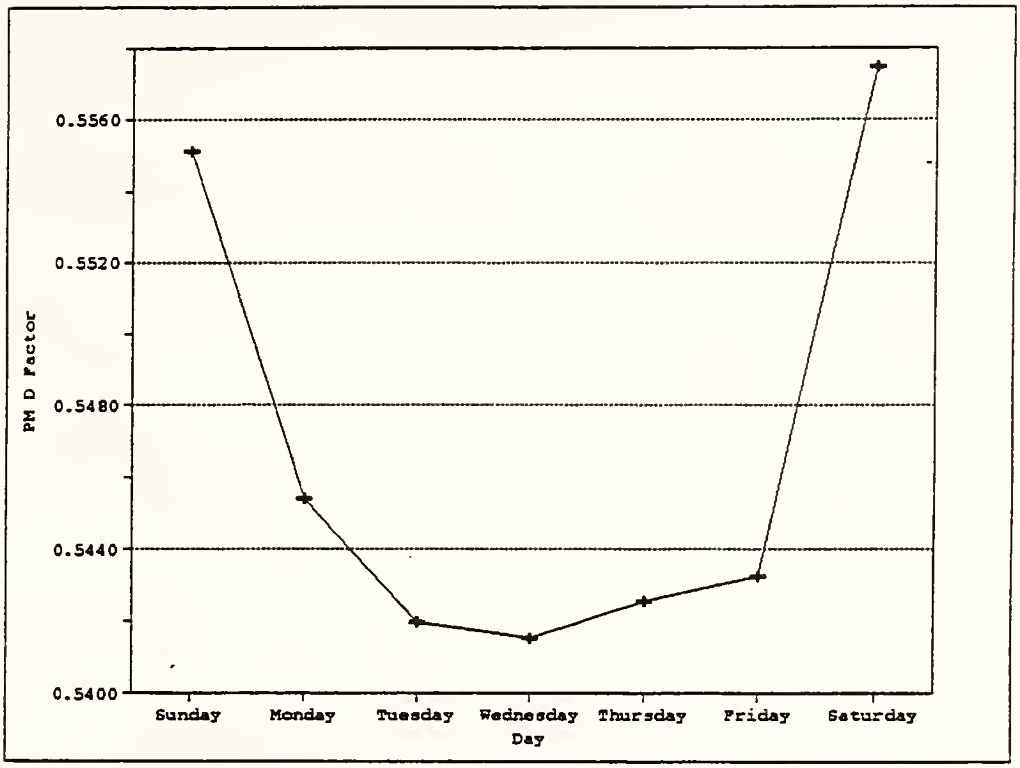

Figure D35 Average Variations of PM 'D' Factor by Day of Week for Rural Interstate

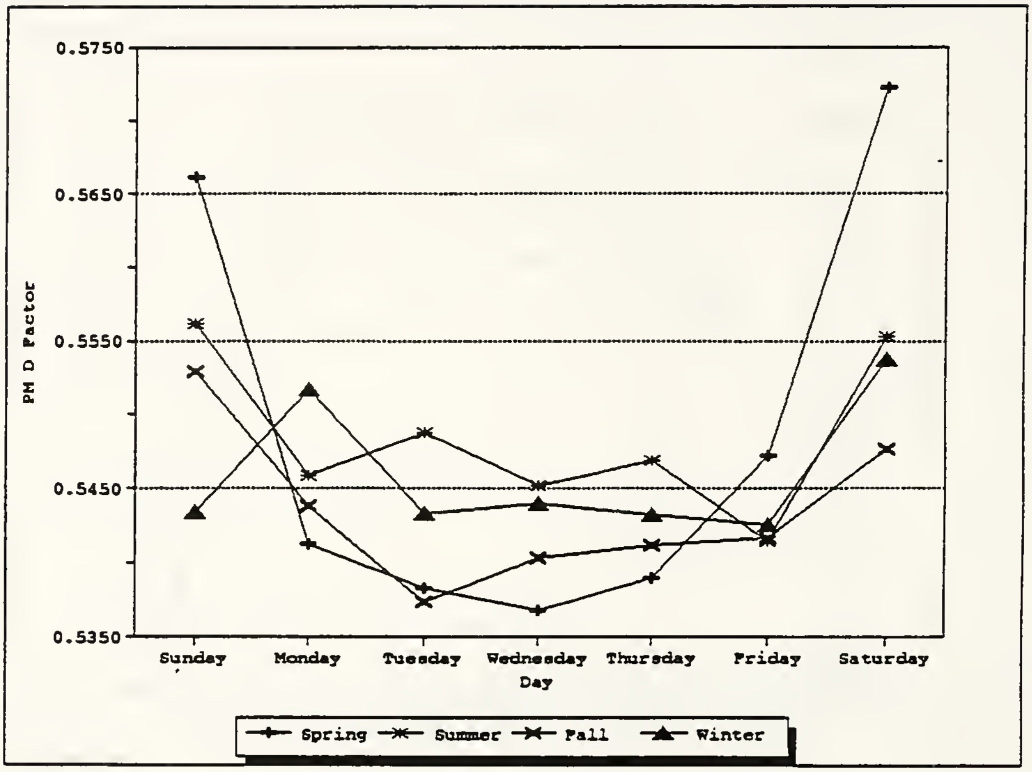

Figure D36 Average Variations of PM 'D' Factor by Day of Season for Rural Interstate

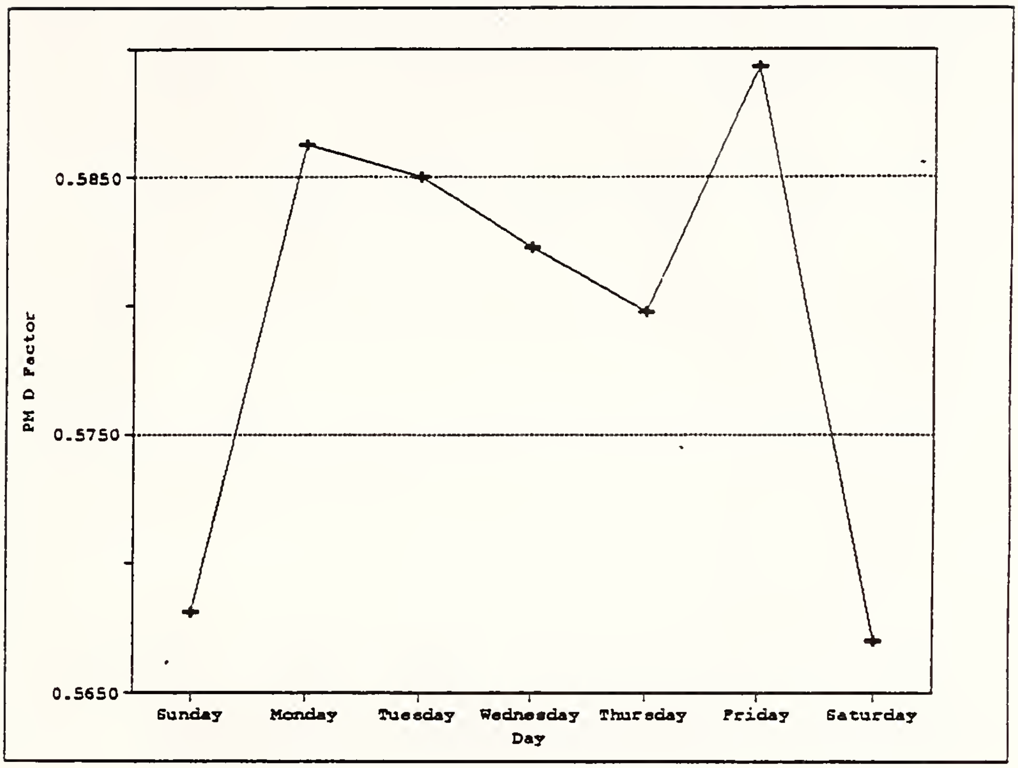

Figure D37 Average Variations of PM 'D' Factor by Day of Week for Rural Arterial

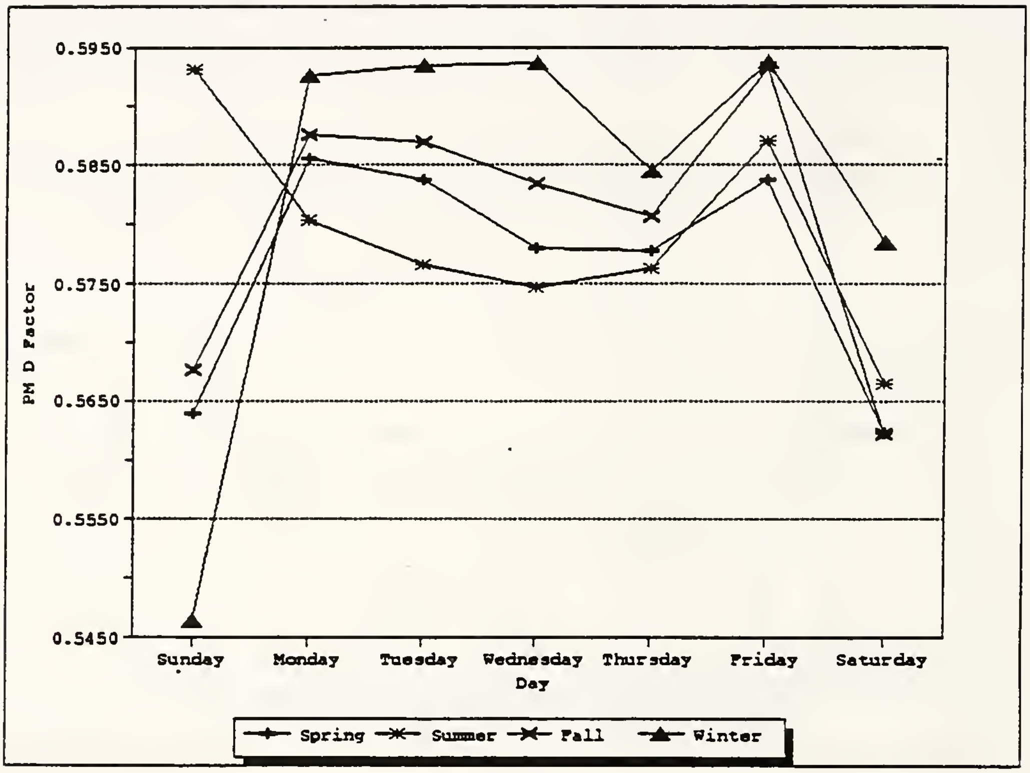

Figure D38 Average Variations of PM 'D' Factor by Day of Season for Rural Arterial

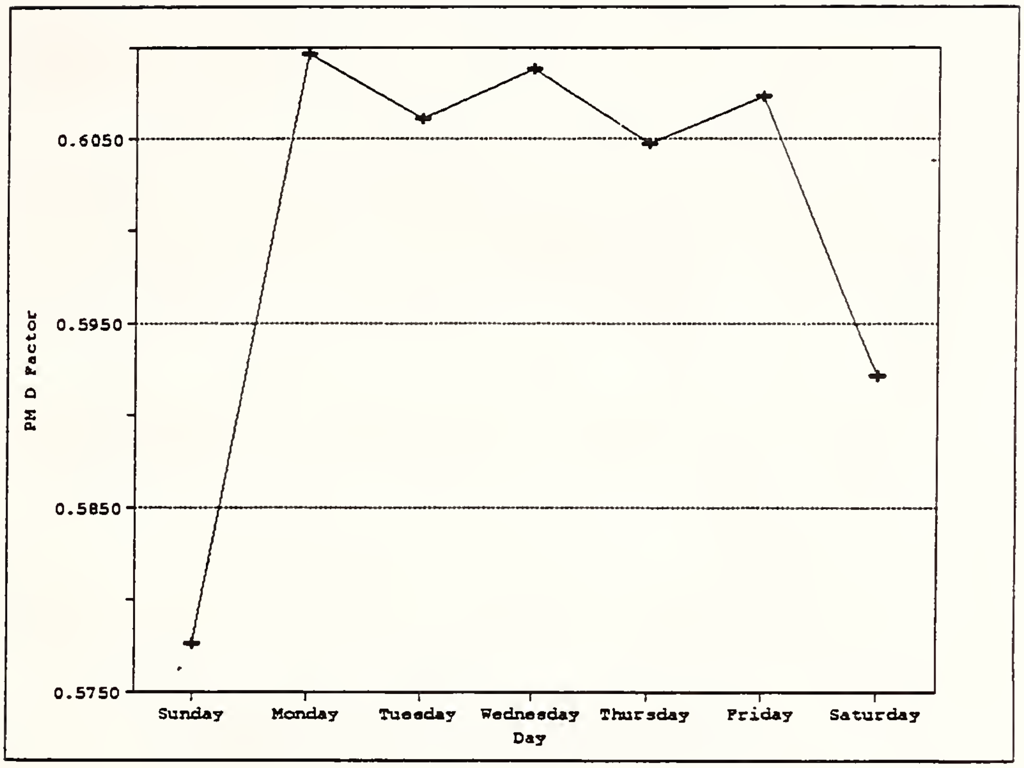

Figure D39 Average Variations of PM 'D' Factor by Day of Week for Rural Collector

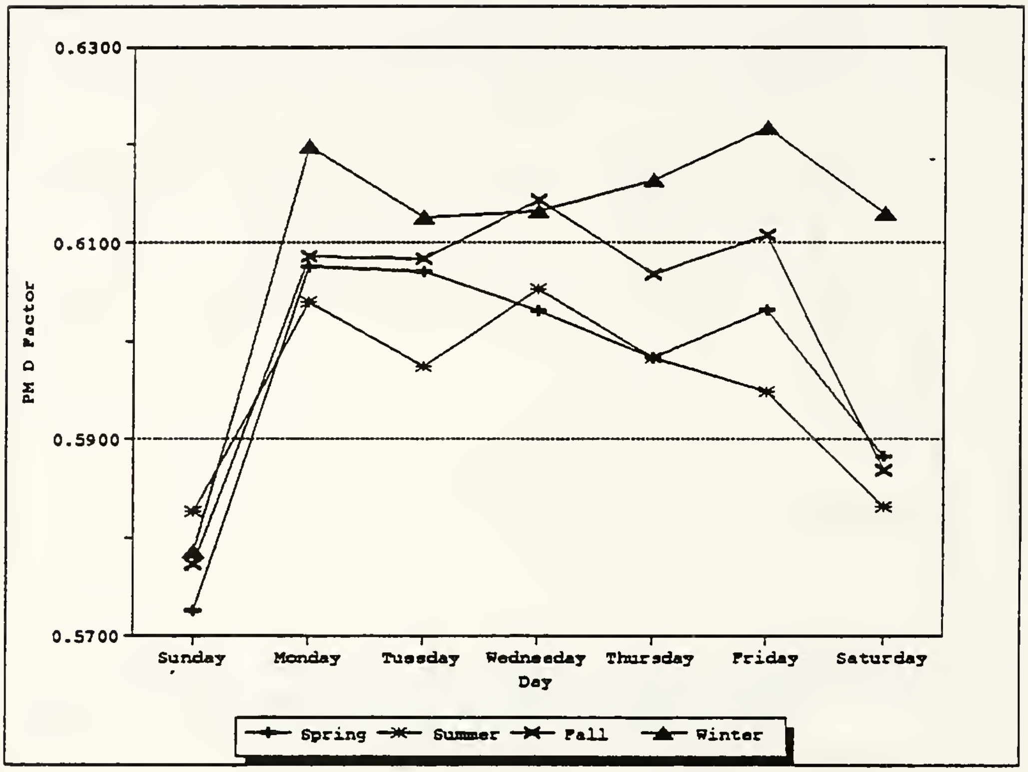

Figure D40 Average Variations of PM 'D' Factor by Day of Season for Rural Collector

Appendix E: A Status Report on the Development of the Indiana Congestion Management Plan

The following is a description of the activities that were performed in developing the Indiana Congestion Management Plan.

1. Literature Review

Prior to the development of the congestion management plan, an extensive literature review was conducted. The literature on congestion management systems was very limited, however, much information was gained on performance measures, congestion mitigation strategies, and the evaluation of urban congestion.

2. Survey of State Transportation Agencies

In order to gain information on the formulation of a congestion management system, a nationwide survey was made of all State transportation agencies. A letter requesting information on the status of each State's CMS and their accomplishments was sent to 49 State DOTs (excluding INDOT). These letters were sent out in June, 1993. At that time, the responses from most States indicated that their progress with congestion management systems was minimal. Several States had retained the services of consulting agencies to develop their CMS, while some States, including Pennsylvania, Tennessee and Utah, had sought the services of State Universities' transportation departments. A few States, which included California, Colorado, Phoenix, Oregon and New York, had made considerable progress with their CMS. Much information and ideas were obtained from these States in formulating the Indiana congestion management system.

3. Survey of Indiana Metropolitan Planning Organizations

A survey was conducted of all Indiana MPOs. The objective of the survey was to determine each area's status with respect to data collection, congestion levels and congestion mitigation activities. A questionnaire was mailed to all twelve MPOs, of which a copy is shown in Appendix C. The results of the survey indicated that the level of congestion in Indiana metropolitan areas is very low compared to other metropolitan areas in the country.

4. Interviews with Officials of Indiana MPOs

Subsequent to the surveys of Indiana MPOs, follow-up interviews were conducted of officials of MPOs. The objective of these interviews was to accommodate ideas and suggestions from officials who were familiar with urban congestion levels and mitigation strategies. These interviews also helped in gaining insight into the MPOs' planning and programming activities. Listed below is a summary of the results of the survey and interviews.

	Questionnaire	Interview
1. Bloomington Area Transportation Study	X	-
2. City of Indianapolis Department of Metropolitan Development	X	X
3. Delaware-Muncie Metropolitan Plan Commission	X	X
4. Evansville Urban Transportation Study	X	X
5. Greater Lafayette Transportation and Development Study	X	X
6. Kentuckiana Regional Planning and Developmental Agency	X	X
7. Kokomo and Howard County Governmental Coordinating Council	X	X
8. Madison County Council of Governments	-	-
9. Michiana Area Council of Governments	-	X
10. Northeastern Indiana Regional Coordinating Council	X	X
11. Northwestern Indiana Regional Planning Commission	X	X
12. West Central Indiana Economic Developmental District, Inc.	X	X

The following information is only pertinent to the ten MPOs who completed the questionnaires. Each data type is followed by the number of MPOs that collect data of that type.

<u>Highway Data:</u>

* Road Miles
  - By functional classification [10]
  - By geographical area [8]
* Lane Miles of Arterials During Peak Period
  - By functional classification of arterials [3]
  - By number of lanes [2]
  - By geographical area [2]
  - By one-way or two-way direction [3]
* Miles of reversible lanes [0]
* Vehicle Miles of Travel
  - By functional classification [10]
  - By geographic area [6]
  - By vehicle type [2]
* Passenger Miles of Travel
  - By functional classification [1]
  - By geographic area [0]
  - By vehicle type [1]
* Average Speed
  - By functional classification [3]
  - By geographic area [3]
  - By vehicle type [1]
* CBD cordon measurement
  - Passenger occupancy [0]
  - Vehicle type [0]
* Traffic Volume and Congestion
  - Number of hours with v/c > x [1]
  - % VMT with v/c > x [1]
  - % PMT with v/c > x [0]
  - VMT with LOS > X [3]
  - Lane Miles with LOS > X [3]
  - LOS for links [3]
  - LOS for intersections [8]
  - Delay on links [2]
  - Delay at intersections [6]
  - Incident duration [0]
  - Delay due to construction [0]

<u>Public Transit Data:</u>

* Land area within 0.25 mile of weekday transit service [5]
* Total system miles [7]
* Total route miles [8]
* Annual unlinked passenger trips [7]
* Annual passengers [9]
* Annual vehicle miles [8]

Demographic Data:

* Population by geographic area [9]
* Dwelling units by geographic area [9]
* Employment
    By geographic area [8]
    By CBD [6]
* Passenger Vehicle Registrations
    By county [4]
    By vehicle type [2]
* Land Areas
    By urbanized area [5]
    By central city [4]
    By central business district [4]
    By federal-aid system boundaries [3]

Almost all of the MPOs interviewed had a program of volume counts. These volume count data could be used to derive the performance indicators recommended in the plan for a prototype congestion management system without additional data collecting effort, and can be subsequently used to identify congested regions/corridors.

Six of the ten MPOs collect volume count data once every three year. Two MPOs collect volume count data only when needed. All MPOs interviewed maintained that the biggest problem with data collection was the limited availability of resources, both financial and personnel. Rail freight facilities and trucking terminals are located in all of the MPOs interviewed.

Five MPOs claimed to have a threshold for congestion at LOS D, and two at LOS C. Overall, peak period congestion does not appear to get too far below LOS D, however, in some specific locations, LOS E, and at a very few other locations, LOS F have been observed. A wide range of strategies to identify congestion are being used. These include public input, capacity analyses, volume counts, turning movement counts, delays, v/c ratios, and vehicle hours of travel.

Almost all areas that experience congestion do so during peak hours. In a very few cases (e.g., I-94 in Northwest Indiana) weekend traffic congestion is experienced. Non-recurring congestion due to roadway incidents is observed most often in Northwestern Indiana (mostly along I-65, I-94 and I-80/94) which experiences heavy interstate truck traffic. Some urban routes in the Evansville area carry between 15 to 20 percent truck traffic.

A wide range of congestion reduction strategies are being implemented or are being studied. These strategies include providing HOV lanes, improving transit services, signal timing changes, providing alternate routes to congested corridors, connecting missing links, adding capacity by building new roads or increasing number of lanes, removing on-street parking, improving road conditions, providing park-and-ride facilities, providing bicycle and pedestrian routes, implementing ridesharing projects, access management, incident management, and intersection improvements.

All MPOs who turned in completed questionnaires had identified corridors/links that were considered to be hot spots for congestion in their respective regions. However, these links have been identified on a subjective assessment and are not based on any specific criteria.

The guidelines presented in the prototype congestion management plan will allow all of the MPOs to make a quantitative and qualitative assessment of congestion, and also facilitate a consistent evaluation of congestion throughout the State. This will eventually allow the State to determine areas that should receive priority with respect to funding of capital improvement projects and for the regions and the State to formulate their long range planning activities.

5. Macroscopic Identification of Congestion

As discussed in the Plan, a macroscopic identification of congestion will be performed using ADT data and the K and D factors. These K and D factors were developed for the State highway system using volume counts from the 60 permanent counting stations located throughout the State and maintained by the Indiana Department of Transportation's Division of Roadway Management. These stations are functionally classified as:

1. Urban Freeway/Urban Interstate,
2. Urban Arterial,
3. Rural Interstate,
4. Rural Arterial, and
5. Rural Collector.

The K and D factors were developed for each of the five types of roadways as well as for different seasons of the year, days of the week, and times of day (AM and PM peak periods). The procedure used in developing these factors are discussed in Chapter 4. The data required for this study were obtained for the three years from 1991 through 1993 from INDOT's Division of Roadway Management. The analysis was conducted using the SAS statistical software adopting the analysis of variance procedure.